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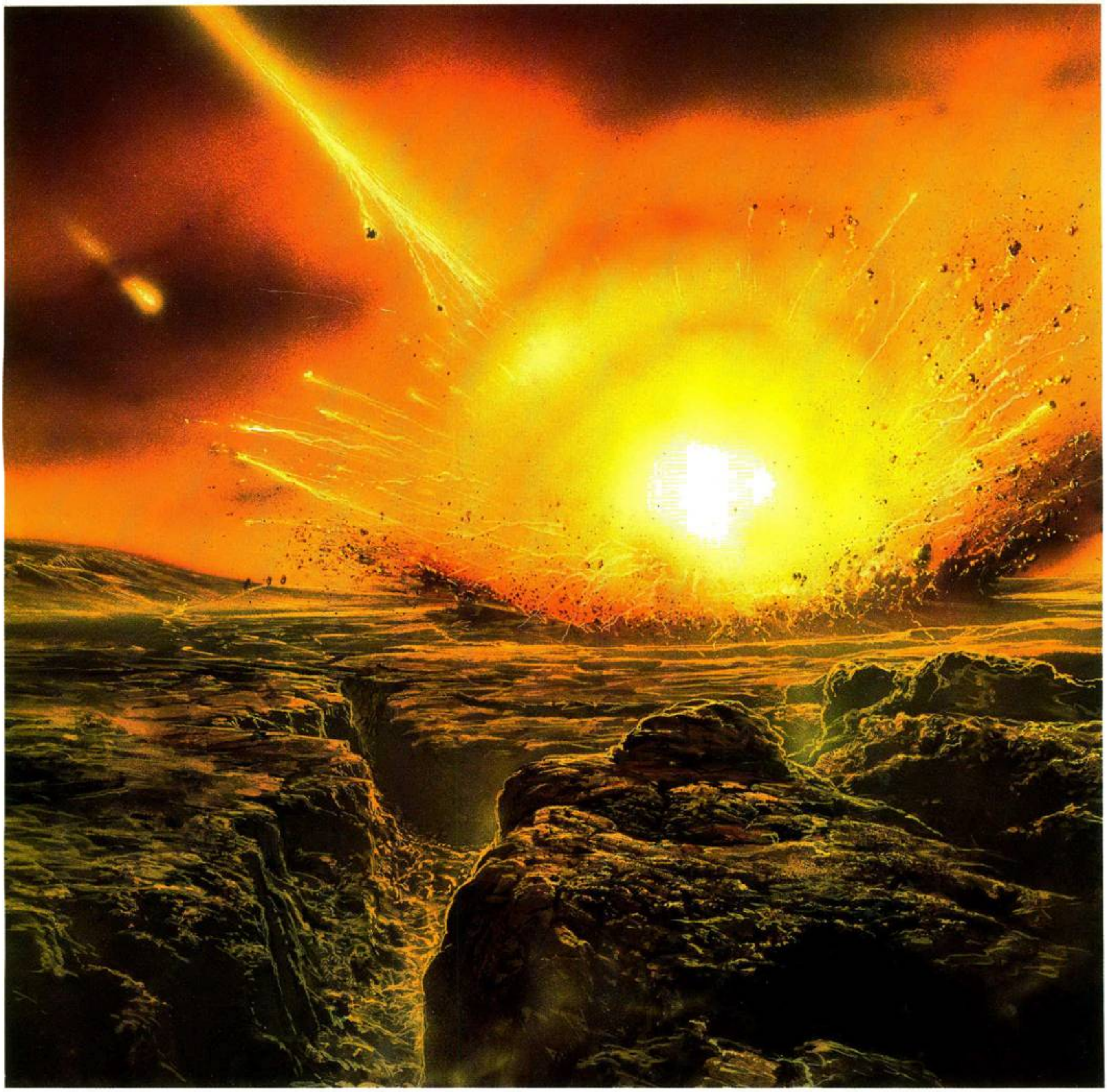

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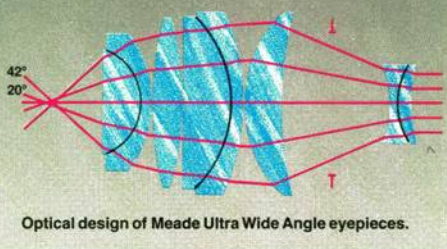


Optical design of Meade Ultra Wide Angle eyepieces.

"Several hundred amateurs had the chance to test the performance of Meade Series 4000 eyepieces at the Astrofest Telescope Convention. Observing Jupiter with your Ultra Wide 8.8mm on a 7″ f/9 Starfire refractor, the huge 84° field encompassed the entire Jovian system. The four moons were resolved as discs, perfectly round even at the extreme edge of the field. Jupiter itself presented a magnificent show with a multitude of bands, small ovals, and festoons, etched in high contrast on the planet's surface. Meade Ultra Wide Angle eyepieces are a unique design that really brings out the best in a high performance telescope."

—**Roland Christen,** President, Astro-Physics Corp., Rockford, IL

Meade® SC Optic

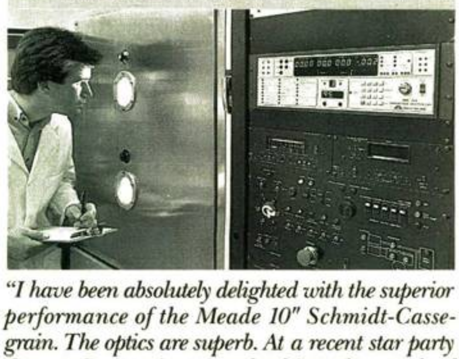
Keeping up with modern optical technology is an expensive process at Meade Instruments—but one which is absolutely vital to our continuing leadership in the production of Schmidt-Cassegrain optical systems. Long recognized as the finest commercially-produced Schmidt-Cassegrain optical systems available, Meade SC optics have recently been still further refined by the addition of important new equipment and processes—additions that assure the potential Meade SC purchaser that his or her telescope is, without qualification, state of the art.

New Super Multi-Coating (SMC): Now included as standard equipment on the correcting plates of most Meade 4″, 8″, and 10″ SCT models, the deep-purple Super Multi-Coating produces the highest light transmission of any antireflection coating in the industry.

Super Multi-Coating on the Meade 8″ 2080/Model 50.

At our Costa Mesa coating facility, Meade technicians use the latest electron beam vacuum coating systems to deposit, at 550°F, the hard, multi-layer chemistry of the SMC—a coating that perceptibly increases image brightness and contrast. Seven correcting plates can be coated on one plate side simultaneously; the plates are then automatically flipped internal to the vacuum system to permit coating of the opposite surfaces.

Electron beam vacuum coater.



"I have been absolutely delighted with the superior performance of the Meade 10″ Schmidt-Cassegrain. The optics are superb. At a recent star party Omega Centauri was resolved into thousands of tiny pinpoints into its core...Many said they were thrilled not only to see so much spiral structure in the Whirlpool Galaxy (M51) but also to see the faint bridge between the two components of M51."

—**L. J. Alfonso,** Boca Raton, FL

Primary Mirror Central Coring: Before Meade 4″, 8″ and 10″ SC primary mirrors can be polished and figured to within exacting optical tolerances, the central perforation, or

al Performance...“Superior...Superb...Breathtaking.”

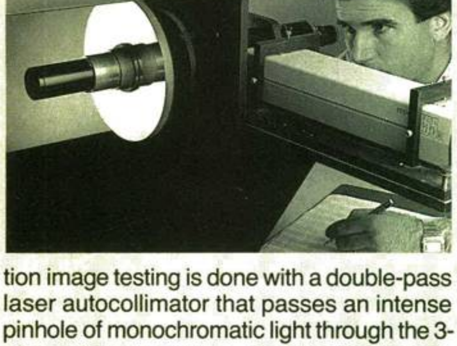
core, of each mirror blank must be precision diamond-ground into the blank. In the Meade optical shaping department this operation is performed on a 5-axis Computer Numerically Controlled (CNC) glass-machining center. The result is a mirror perforation (ready to accept the primary mirror baffle and focusing mechanism) that is within arc minutes of perfection—a precision that, with minor final adjustment by optical alignment technicians *(see below)*, virtually eliminates mechanically induced aberrations in the Schmidt optics.

CNC coring of SC primary mirrors.

“When unpacking my Meade 10″ SCT I realized that the amount of work which had gone into making this instrument was incredible...every detail was perfect down to the last nut and bolt. On the first clear night I took the scope out to check the optics. Quite simply the views were breathtaking! Star images matched textbook versions letter for letter, showing perfect symmetry in and out of focus.”
—**J. Spang,** Chorely, England.

Optical Testing: As each Meade 3-element SC optical set (primary mirror, secondary mirror, and correcting plate) progresses through the grinding, polishing, and final hand-matching stages of development, it is continuously tested and re-tested for zonal irregularities, smoothness, and correction. Intermediate testing is performed using the Foucault and Ronchi methods; final diffraction image testing is done with a double-pass laser autocollimator that passes an intense pinhole of monochromatic light through the 3-element system *twice*, enabling the technician to detect errors (at an effective magnification of 1000X) beyond the observable limit of the field user. If we seem unusually confident in the capabilities of Meade Schmidt-Cassegrain optics, it is because we know that every optical set is put through this battery of over 30 separate optical tests and inspections before the optics are mounted in the optical tube and shipped to you.

Autocollimator testing of an 8″ SC system.



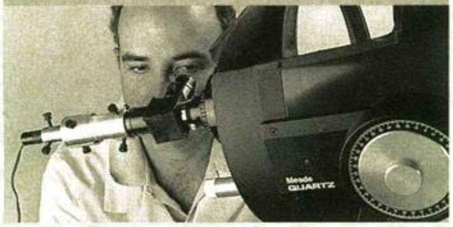
“Using my Meade 8″ SCT under just fair seeing the 1.0 arc sec double Zeta Boötes was beautifully separated, with plenty of dark space between the circular Airy discs. At lower power the four stars of Epsilon Lyrae were also cleanly separated and a beautiful sight, with all in the same field.”
—R. Knight, Stow, OH

Interferometric testing of diagonal flats.

Diagonal Flat Testing: Integral to the functioning of any high-performance Cassegrain system is the optical smoothness and flatness of the diagonal surface. Every Meade diagonal mirror is tested for flatness on a Fizeau laser interferometer; mirrors which pass this test are coated with enhanced aluminum and mounted in their machined diagonal housings.

Optical Alignment: Finished, individually matched 4″, 8″ and 10″ SC optical sets are sent to the optical alignment department, where each set is placed into a special cut-out optical tube that permits rotation of the optical elements about the optical axis. (The relative rotational orientations of the Schmidt-Cassegrain primary mirror, secondary mirror, and correcting plate are *not* arbitrary.) Rotation of the optics, while the technician observes an artificial starpoint under controlled laboratory conditions at high power, yields the unique relative orientation that cancels out any residual aberrations of the system. With optimal orientation thus fixed, each optics set is placed into the machined housings of its optical tube. The optical system is once again tested for roundness, regularity, and consistency of the diffraction image inside and outside of focus. Only after passing this final test is an optical tube system ready to become part of a Meade Schmidt-Cassegrain telescope.

Rotational orienting of 10″ SC optics.



“As a former staff member at Mt. Wilson and Palomar Observatories, I have had access to some of the finest optics ever produced. The Meade 10″ f/6.3 2120 is the most impressive commercial instrument I have yet seen. Under critical examinations, stellar diffraction patterns are superb both inside and outside of focus. Focal images are sharp and crisp; in applications where high contrast characteristics are important (such as in observing the ‘eyes’ of the Owl Nebula, M97, or structural variations in the main spiral arm of the Whirlpool Galaxy, M51) the telescope performs impressively. The image of Saturn is beautifully defined, showing subtle belt detail and the crepe ring with surprising boldness for a 10″ telescope.”
—Paul Roques, Williams, AZ

Final quality control inspection.

Quality Control: As part of the final quality control inspection, an inspection which also includes detailed checkout of the telescope's mechanical and electronic functioning, each optical system is examined for any coating sleeks or scratches which may have occurred in the manufacturing process. Telescopes which pass this series of tests are then packed for shipment to authorized Meade dealers throughout the world.

Every Meade Schmidt-Cassegrain telescope must pass more than 135 optical, mechanical, and electronic tests, inspections, and quality control procedures before it is judged ready for shipment. If you're as committed to optical quality and performance as we are, then see what a Meade 4,″ 8,″ or 10″ Schmidt-Cassegrain can do for your observing program. See the telescopes that combine the finest, most integrated electromechanical systems, including the revolutionary Smart Drive,™ with the highest level of optical precision in the industry today.

Complete Catalog Package #91C—$3.00—Includes catalogs and bulletins on the entire range of Meade astronomical telescopes, Series 4000 eyepieces, and accessories.

Dealer Locations and Assistance—For your nearest Meade dealer location, or for free telescope information and assistance, call Meade Instruments toll-free from anywhere in the continental U.S.A. (except California): **1-800-854-7485.** From all other areas, including California, call direct (714) 556-2291.

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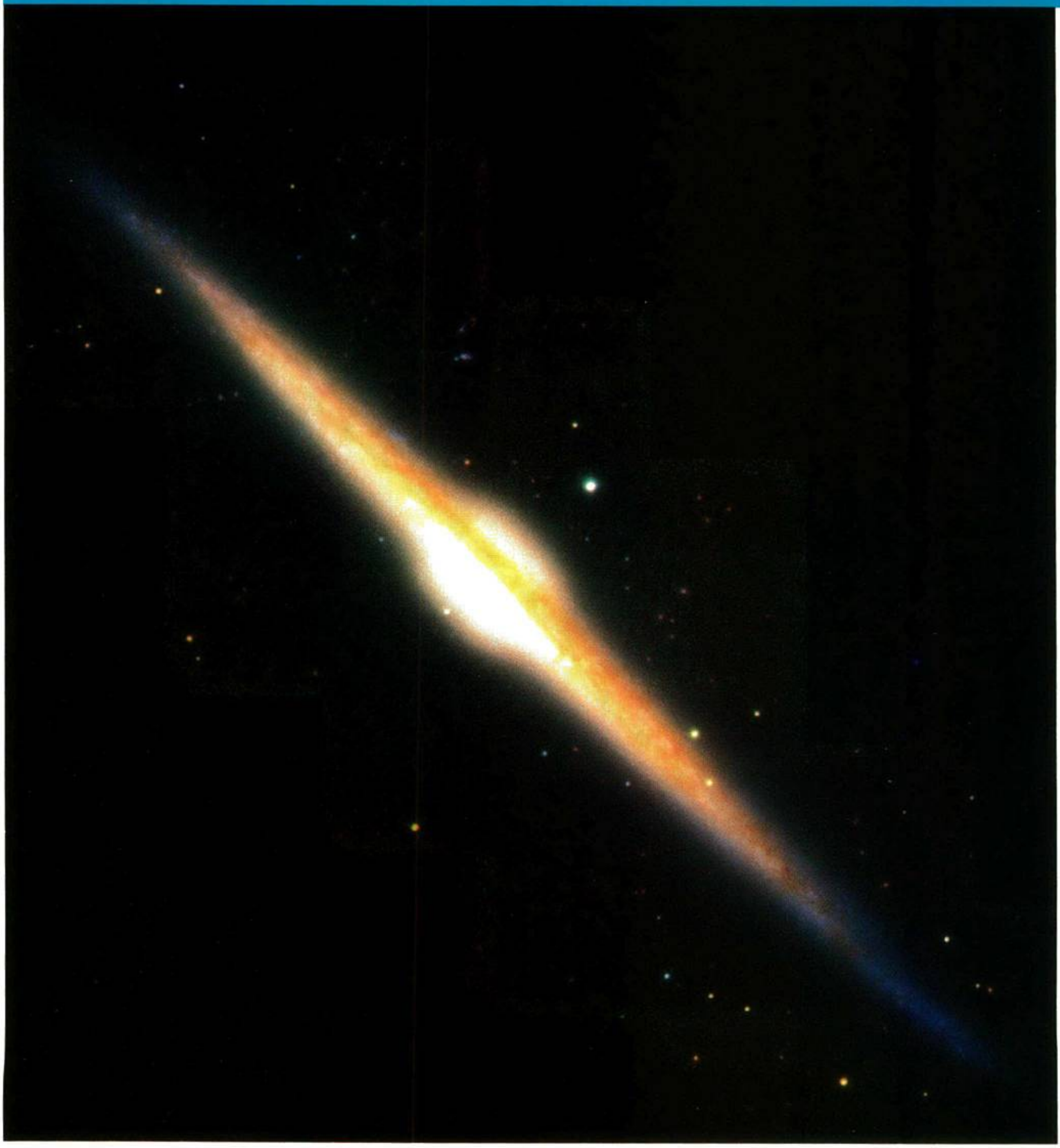
ON THE COVER: The thick atmosphere of Venus shatters an incoming meteorite and the hail of debris leaves a surface scar unique to Venus. For Magellan's new views of these and other Venusian surface features, see page 32. Art by Robert Eggleton.



AN INFRARED VIEW of the galaxy NGC 4565 shows its normally dark dust lane as very red. The red areas represent infrared light, which passes more easily through obscuring dust than visible light can. This composite is the result of ten 600-second exposures taken in blue light, sixty 50-second exposures in the infrared at 1.2 microns, and sixty 50-second exposures at 2.1 microns. Exposures taken by Richard J. Wainscoat with the University of Hawaii's 2.2-meter reflector on Mauna Kea and an infrared CCD camera being tested for the Hubble Space Telescope. For the latest news from Hubble see pages 42 and 46.

ASTRONOMY®

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The Audit Bureau

Behind the Scenes

AURORAS, ASTEROIDS, TIME WARPS, AND AWARDS

Auroras first. If you've been watching the Sun on a regular basis, in early and mid-June you saw an enormous sunspot. Furthermore, if you've been watching the sky even casually and live in any of the northern states, you were treated to a week of incredible auroral displays. Too little time has passed for the flood of pictures or reports we expect to arrive soon from our readers, but next month we promise you a story and pictures for your enjoyment.

Next, asteroids. Senior editor Robert Burnham has joined the ASTRONOMY asteroids as 4153 Roburnham. The official citation recognizes Robert's role in helping to make ASTRONOMY the astronomical magazine with the number one circulation in the world. Roburnham joins 3684 Berry, 3617 Eicher, and 3505 Byrd as one of ASTRONOMY's regular writers or editors whom the International Astronomcal Union has honored with an asteroid name.

Then time warps. As we put the finishing touches on this issue of ASTRONOMY, the solar eclipse is four weeks in the future. Here in the office, we're still gathering and checking telescopes, cameras, lenses, and tripods for our expedition with Twilight Tours to Baja California and the cruise aboard the *Viking Serenade*. Yet for the readers of this issue of ASTRONOMY the eclipse is an event in the past; the eclipse has already happened and it's mid-August for you. This time warp means that our first eclipse report will appear in the October issue of ASTRONOMY, which is due to arrive in early September. Thanks for sending your reports and photos. We know you'll be waiting patiently (or impatiently) for the results. . .

Last but not least, an award for ASTRONOMY. The Astronomical Society of the Pacific recently announced that its board of directors has chosen me and the staff of ASTRONOMY to receive the Klumpke-Roberts Award for 1991. This award was established to recognize outstanding contributions to the public understanding and appreciation of astronomy — and that, of course, is and always has been ASTRONOMY's most important editorial mission.

We at ASTRONOMY are delighted and honored to be selected for the Klumpke-Roberts Award. To the ASP and to our readership we pledge continued and redoubled efforts to raise public understanding and appreciation of astronomy. On behalf of the staff of the magazine, I wish to thank the Astronomical Society of the Pacific for their recognition and this award.

Sincerely,

Richard Berry

Richard Berry
Editor-in-Chief

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Letters

Reader to Reader

I have a solution to the mosquito problem Carol Loveridge described in her April 1991 Viewpoints article. Years ago, a letter appeared in our local newspaper written by a woman who said that she was a keen gardener but that her enjoyment of gardening activities had waned because of many mosquito bites. She had tried various insect repellents, but with little success, and could the editor suggest a more effective remedy.

A week later the editor thanked readers for the numerous suggestions he had received and published only one letter, sent to him by the Department of Entomology at the British Museum and giving the following formula:

1 fluid ounce of oil of eucalyptus
1 fluid ounce of oil of citronella
1 drop of pure carbolic acid

As a person fond of trout fishing at dusk, I was painfully familiar with the mosquito problem and had, myself, tried various repellents without much success. I had the concoction made up for me by a local pharmacist and a few evenings later took a bus to some woods near a lake, an area I knew one didn't much linger in during the evening. The trial was successful. This mixture is pungent and persistent and mosquitos don't like it one bit. So a bottle of this is now an essential item of vacation equipment for me.

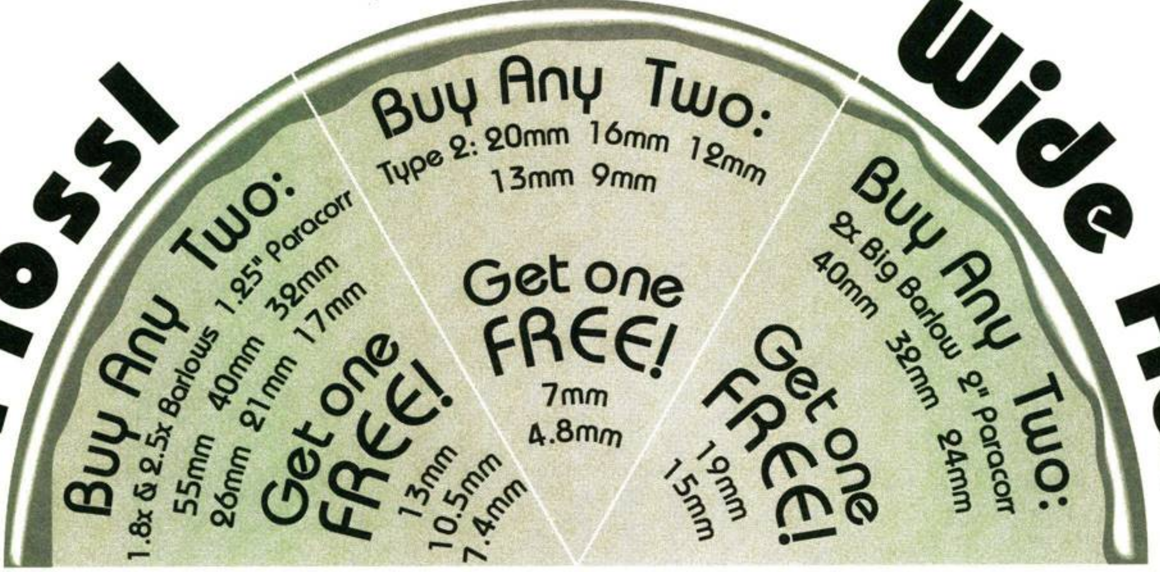
I hope that this solution from across the sea benefits others like me who like star gazing — and trout fishing, too. — *E.W. Brisley, Cornwall, England*

I am another teenage astronomer who enjoyed reading Thomas Pannutis's "Ballad of a Teenage Astronomer" (Viewpoint, December 1990). And like Thomas May (Letters, April 1991), I have been called "weird" just because of my interest in astronomy.

I have been interested in astronomy through most of my childhood years, but until last December, I had never really gone outside with a pair of binoculars and actually located specific constellations. Your great magazine has played a major part in helping me identify the various constellations, since I keep your magazine open to the all-sky map as I search the dark skies.

Articles such as "How to Find a Lunar Volcano" (December 1990) and photos of various nebulae and planets have made me realize I am missing out on some of the excitement because I do not have a telescope. My binoculars are 7x35mm, which is just powerful enough so that I can pick out the faint

Plössl Nagler Wide Field



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Tele Vue is heading into its 15th anniversary year and is delighted to celebrate it with you. Through the past 10 years of developing innovative astronomical equipment, we have made many friends and are proud of the reputation we have earned. As a special "thank you" this offer of free eyepieces is available until September 30, 1991.

The more eyepieces you order, the more Free items you receive. So, get your friends and club members together and pool your orders for best selection. This offer applies only to merchandise in-stock at time of order.

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"My observations with the 20mm Nagler rivaled the detail in good astrophotography. I was amazed and deeply satisfied. Thank you for the ultimate eyepiece."
- Ben Cohen, CA

"After seeing the recent ad with all the letters touting (competitive) eyepieces, I had to respond. I consider myself a very critical observer. Using a 10" f/5.6, I found the Tele Vue 40mm Wide Field superior to the (competitor) in sharpness, both center and edge. I have used very expensive and inexpensive eyepieces. I have found none optically superior to Tele Vue for astronomical purposes."
- Kenneth Drake, Observing Chairman, Houston Astronomical Society

"Your eyepiece has given me the most pleasant case of insomnia imaginable"
- Tom Lorenzin, Author of 1000 + Guide to Deep Sky Observing

"Despite the presence of no less than seven optical elements, Nagler eyepieces provide images which are noticeably brighter than those obtained with many quality Orthoscopics, with superb image sharpness and contrast. Even though these oculars are quite expensive, the serious planetary observer would do well to consider employing this type."
- From Observing and Photographing the Solar System by Don Parker

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moons of Jupiter. But I'm finding I quickly become bored or frustrated because I do not have a tripod and cannot hold my binoculars steady enough to see objects directly above my head. I am also not satisfied with seeing the Orion nebula, Mars, or Jupiter as only a bright dot in the sky.

I read somewhere that it does not matter how much magnification you have but the aperture of your telescope. Is that true? Also, I was wondering if you could give me some tips on what to look for in a cheap telescope (under $400) so that I can see the planets up close like the pictures from "Solar System Roundup" (Reader Reports, May 1991). — *Simon Ko, Ontario, Canada*

For suggestions about selecting a telescope, consult the October 1990 issue of ASTRONOMY, which carries our 1991 Telescope Buyer's Guide. Or if you can wait, consult our 1992 guide, which will appear on the newsstands on October 15, 1991. Good luck.

How Wide? How Far?

Your AstroNews item, "Asteroid Narrowly Misses Earth" (May 1991) was of particular interest to me, as I was on hand at Oak Ridge Observatory in Harvard, Massachusetts when the 61-inch Wyeth was used to confirm the sighting by David Rabinowitz at the University of Arizona. I am confused by the final paragraph of Joseph Allen's coverage, however, where he notes that prior to the sighting of 1991 BA, the closest sighting of an Earth-approaching asteroid came in March 1989. "The asteroid was about 100 meters in diameter and passed at a distance of 10 times that of the Moon," writes Mr. Allen. I make that 2,000,000 miles or so.

Because such close calls are a rarity, I believe I can assume that asteroid 1989 FC, which was found in photos taken by Arizona's Henry Holt at the Mount Palomar Observatory on March 31, 1989, is Mr. Allen's reference. At the time of discovery, NASA's Bevan French was quoted widely with estimations of a half-mile diameter [about 800 meters] and passage roughly 500,000 miles from Earth, merely twice the distance separating the Earth and Moon. Why the huge discrepancy in description? — *James L. Degan, Deerfield, New Hampshire*

The key phrase relating to Mr. French's description is "at the time of discovery." Estimates of an asteroid's size typically change after many observations have been made and the orbit is refined. The best numbers for 1989 FC show the asteroid passed within 465,000 miles of Earth at closest approach and, depending on who's albedo estimates you believe, measures between $^1/_{16}$-mile and $^1/_5$-mile across (100 and 300 meters, respectively).

How Bright Was It?

The picture caption in the article on Comet Halley in AstroNews (June 1991) says that the eruption has made the comet 1,000 times brighter than expected (7.5 magnitudes). The text says the comet is 6 magnitudes brighter than expected, which would be 251 times brighter. Which is correct, the text or the caption? — *Robert W. Ashcraft, Amarillo, Texas*

The discrepancy appears because the people who discovered the outburst measured it at 6 magnitudes brighter than predicted, while astronomers observing it a few days later found it to be 7.5 magnitudes brighter. As with all comets, different observers often measure different brightnesses.

Pixel Power vs. Film Grain

In recent editions of ASTRONOMY, we've seen a number of articles on what we might call the "CCD revolution." I have read with a certain amount of interest articles on equipment and use as well as seen results by amateur astronomers.

At last, I believed, the astronomer is using what the professional has used for quite some time. CCDs were expected to revolutionize the amateur astronomy community — bright images, computer processing and, above all, ultra-short exposure rates. The results have been presented and the CCD fans are all in heaven — at least at ASTRONOMY.

It might well be that I'm the only one who thinks so, but I really think CCD images are ugly! It doesn't matter if it took 5 or 30 seconds to create the image, I'm still not impressed. What is a CCD image anyway but a gathering of squares with different luminosity?

Once upon a time I had the impression that amateur astronomers fought against grainy film. The hunt for fast, fine-grained film has probably been put to an end with the Fuji Super HG 400, so what's the idea of a CCD? It certainly can't be said to be fine-grained.

Well, that's enough sour comments for now. I'm probably nothing but an ultra-conservative, narrow-minded, 18-year-old Norwegian boy who cannot accept the signs of the times. I just felt I

Genesis Owner Turned Into Zombie!

Gentlemen:

I would like to say a few words about my new Genesis. I live in a relatively light polluted area, and own an 8" SCT which I have used for about two years. During this time there have been many deep sky objects which I have been unable to locate from my back yard.

I bought Genesis because I wanted a telescope that I could set up quickly to use at home on week-nights. When I began using Genesis, a few weeks ago, I was surprised to find many objects that have eluded me during the past two years. I was even more surprised when I realized that I had been looking in the right places all the time. These objects showed up in Genesis, but not in my 8" SCT.

My back yard experience with Genesis encouraged me to take it to my dark sky observing site which is, at an elevation of 5000 feet above sea level, in the Sierra Nevada Mountains. What I saw there was, in many cases, better than photographs in magazines. I was able to resolve globular clusters to a greater degree than publications indicate.

I didn't expect Genesis to be this good. It really is better than I imagined.

There does seem to be one problem with Genesis. My short week-night observing sessions have become anything but short, and I frequently arrive at work feeling and looking very much like a zombie. I guess that no telescope can solve all of your problems. In any case, thanks for the ones you did solve.

- George N. Storm, California

Photo by Jim Riffle

Unsolicited comments from warranty cards

- *It's beautiful, from case to scope.* C.C. The Netherlands
- *Fantastic! Great photo resolution, best optics ever owned and I'm a Hasselblad & Nikon fan. Now my best item.* D.B. New Jersey
- *This is my 1st scope and I'm having a wonderful time finding the limits of the instrument and my locating abilities.* G.P. New Jersey
- *Very pleased with your new improvements.* J.F. California
- *Even though cost was more than an 8" SCT with mount, quality & convenience won out. I will only use Tele Vue optics, mount and accessories.* W.B. Indiana
- *The telescope lives up to its expectation.* T.W. England
- *Wanted a 2nd telescope that was portable, delivered wide fields and superb images. Genesis is all I hoped for. The sharpness is astonishing and it's very portable.* G.H. Canada
- *Sold my 8" SCT looking for better images.* P.F. New York
- *Fantastic! My wife could not see Trapezium etc. with old scope. Now can't get her away from eyepiece: you have right to be enthused about your product.* W.J. Canada
- *I just wanted to have one excellent telescope to do astrophotography. Fantastic. Awesome.* J.J. California
- *Beautiful equipment - Total satisfaction with first use. Keep up the good work.* M.C. Ohio
- *I wanted a very high quality refractor. I was told by many - "This is it." This is a beautiful instrument!* M.F. Florida
- *Remarkable! I always wanted a 4" fluorite refractor. Sold my (8" SCT).* T.S. Indiana
- *Compactness & quality - a beautiful, fantastic instrument.* J.V. The Netherlands

- *It's the best 4" refractor made.* A.A. California
- *I was looking for the best first telescope I could buy. Something small. I never saw images clearer and more distinct than in Genesis.* G.D. Canada
- *Genesis is the only scope in the race. I wanted the best and believe I got it.* E.S. Australia
- *As the apparent equal of a (Maksutov), with the added RFT capability, Genesis is 'the', to me, obvious choice for portable astronomy. I'm completely satisfied.* R.A. Georgia
- *Very Impressive - my first view was of Pleiades with a 40mm Wide Field. The observation was remarkable, crisp, bright and jewel-like.* P.L. Massachusetts
- *The best on the market.* E.B. England
- *I bought this telescope without having seen it in-person, based on its specification & your reputation for quality. As usual, I got more than I expected with Tele Vue products...* K.L. Texas
- *My friend borrowed it & won't give it back!!* T.L. Canada
- *I wanted portability and very high quality optics. I have waited many years to be able to afford this telescope, - it was worth waiting for.* P.H. Australia
- *Superior to other 4" scopes on offer.* Z.V.S. South Africa
- *Had SCT, poor contrast/resolution. Tele Vue just the opposite, also it's more portable.* W.S. Connecticut
- *I purchased this instrument because:*
  1) Apo-refractor - basic design
  2) Tele Vue reputation
  3) Dealer owns same model
  U.B. Canada
- *Genesis is as good as gold...Maybe better!* F.G. California
- *I compared specs of Tele Vue vs (other high performance refractors); T-V best choice for $.* R.A. New Hampshire
- *Magic.* C.H. England

My sincerest thanks to all who've written us with such kind comments. I look forward to reading yours.

Al Nagler

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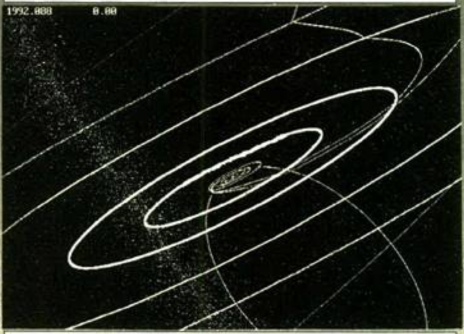
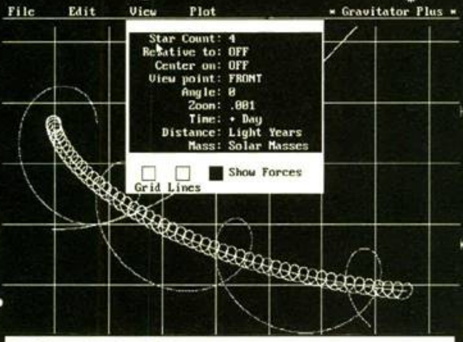


☐ **Howington Orrery**™ Includes Sun, and all 9 planets displayed on screen in the correct positions for any date chosen. Halley's comet included and the Voyager I & Voyager II space probes . User's manual guides you on a tour of the solar system. See the launch of the Voyagers and the encounter of Voyager II with Neptune. Check out Halley's comet at the Sun in 1986 or look ahead to 2062. Speed of the display updates can be set from slow (1.5 hours) to fast (5.5 years). Press keys 1 to 9 to identify each of the 9 planets on the screen. Draw the orbit of each planet or track each planet's movement with a trail on screen. PageUp/PageDn keys increase or decrease the field of view. Home and End Keys take you to Earth's orbit or to Pluto's orbit. Set time to run backwards to replay an event or to see the solar system in the distant past. This fascinating program will be a long lasting source of information and entertainment. IBM & compatibles, Hercules,CGA,EGA,VGA **$39.95**

☐ Have an original, high quality program? We may want to publish it. Please write for our Programmer's Guidelines. Please do not send software at this time.



```
Star Count: 4
Relative to: OFF
 Center on: OFF
View point: FRONT
     Angle: 0
      Zoom: .001
      Time: • Day
  Distance: Light Years
      Mass: Solar Masses
```

☐ **Gravitator Plus**™ - Adds these features: Uses pull-down menus and mouse(optional) for easier operations. With EGA /VGA uses 16 color mode; you can assign colors to bodies. Grid system allows better evaluation of systems. Display distances between bodies and the forces between pairs of bodies. System can be fixed to a specified body for easier tracking, more. IBM Her./CGA/EGA/VGA. Dot or laser printers. **$89.95**

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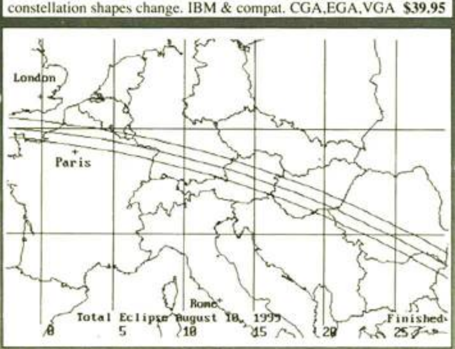

☐ **SunTracker Plus**™ All features of the regular SunTracker plus: Hi-res, 16 color EGA/VGA modes. Width of totality path is visible on screen by plotting the bounds of totality = 100%. Eclipse paths plot in black for total eclipses; annular paths in white. Bounding lines are red, oceans blue and land areas are green. Accepts as input the Saros number, a numbering convention for 18 year intervals between similar eclipses. Use Saros numbers to watch a series of eclipses. A Saros series table for 5729 BC to 6627 AD is included. Screen includes path summary table, date of the eclipse and Saros numbers. Above illustration is Super version. Plus uses full world maps(various orientations)IBM EGA,VGA. **$49.95**
Super version Plots eclipse paths on variable scale maps in color. You give center of map & overall size in long./lat. Add titles, cities,etc. Plus version included as part of Super version. IBM EGA/VGA. **$89.95**
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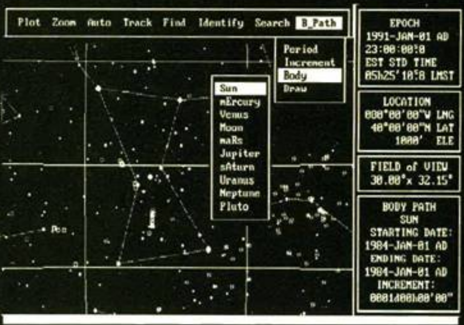
☐ **GalaxCrash**™ Simulate the collisions of galaxies on screen. Computer calculates the gravitational forces on the stars so that they move in accordance with Newton's laws of motion to show the typical results of colliding galaxies: whirlpools, rings, bridges and other structures. You specify the number of stars in the first galaxy & the mass, location and the velocity of the second, colliding, galaxy. Get a 3-D plot, with an overhead view and a side view, of the two galaxies. Fascinating to watch! IBM & compatibles, CGA,EGA,VGA **$29.95**

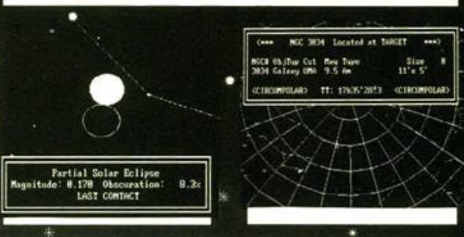


```
EPOCH
1991-JAN-01 AD
23:00:00:0
EST STD TIME
05h25'10:8 LMST

LOCATION
000°00'00"W LNG
40°00'00"N LAT
1000'  ELE

FIELD of VIEW
30.00°x 32.15°

BODY PATH
SUN
STARTING DATE:
1984-JAN-01 AD
ENDING DATE:
1984-JAN-01 AD
INCREMENT:
0001d00h00'00"
```



```
Partial Solar Eclipse
Magnitude: 0.170  Obscuration:  0.3%
LAST CONTACT
```

```
(***    NGC 3034  Located at TARGET    ***)
NGC# ObjTyp Cst  Mag Type           Size
3034 Galaxy UMA  9.5 Am             11'x 5'
(CIRCUMPOLAR)   TT: 17h35'20:3   (CIRCUMPOLAR)
```

☐ **LodeStar Plus**™ All features of 2.1 version and these additions: High resolution 16 colors with EGA/VGA modes. Includes all 7840 NGC galaxies, clusters, nebulae, etc. Options to plot RA&Dec grids and constellation boundaries. Automatically search for and see solar and lunar eclipses, planetary conjunctions, occultations. Plot the paths of Sun, Moon & planets on sky view. Video mode lets you record screens to display later for reference or demonstrations. Calculates parallax, nutation and aberration and ephemeris time corrections for high accuracy. Supports any of 300 printers, dot, laser or jet. Sophisticated interface including pull-down menus and mouse support to easily access all 78 functions. IBM & compat. 512K, Hercules, CGA/EGA/VGA. Works with or w/o co-processor. 16 colors w/ EGA/VGA **$149.95**

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had to share my views with the readers of ASTRONOMY. To all of you, from the land of ice and snow, enjoy ASTRONOMY with or without CCDs. — *Arild Mikalsen, Mjondalen, Norway.*

I read your letter with great interest. You have accurately expressed the reasons why many people still regard CCDs with distrust and suspicion. Like any new technology, CCDs threaten to change the world, and we humans don't like to change the way we do things.

You are 100% correct when you say that a CCD image is nothing but a collection of squares with different luminosities. In precisely the same way, a photograph is nothing but a collection of black specks. All "fine-grained" means is that the specks are smaller than they used to be.

What film and CCDs really both do is to make images. What you don't like about CCDs is that the squares are too big and look too clumsy. By the same token, you don't like films when the film grain is too big.

Photographic film is a technology that's 150 years old, while CCDs are only 15 years old. The CCDs we see today produce coarse images and cost too much for most people to buy. That will change. Just as today's film is better than film made in the year 1900, CCDs made in the year 2000 will be much better than CCDs today.

I don't believe that you are really an ultra-conservative and narrow-minded person as you say you are. Rather, I think that you deeply appreciate the image quality and resolution that present-day films offer the amateur astronomer. I do too.

But the world is big enough to contain both film and CCDs. Neither one makes the other worthless. There will be times when film is best and there will be times when CCDs are best. I do not believe that CCDs will ever fully replace film any more than photography has replaced writing. We still write because that is the best way to express ourselves at certain times, and we will still photograph long after there are many more CCDs in the world than there are today.

I wish you a pleasant summer also. — *Richard Berry* □

ASTRONOMY welcomes comments, suggestions, and additional information on articles and astronomy in general. Send your letters to: ASTRONOMY letters, P.O. Box 1612, Waukesha, WI 534187. Letters may be edited for length or clarity.

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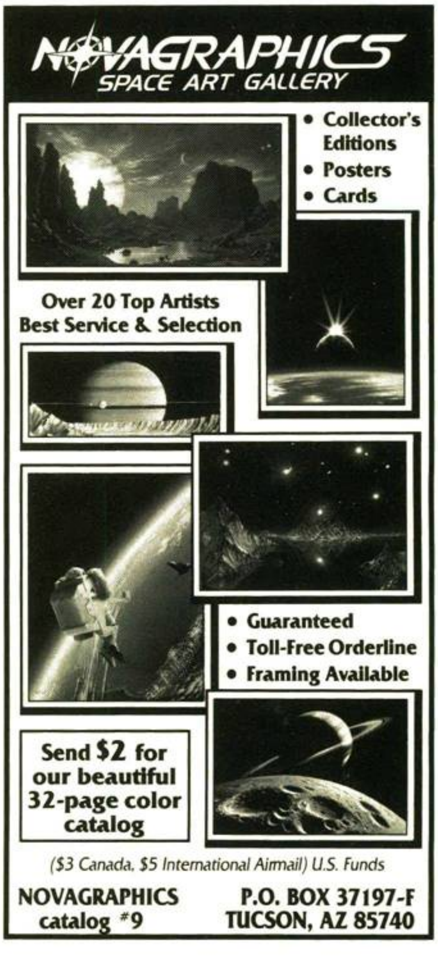

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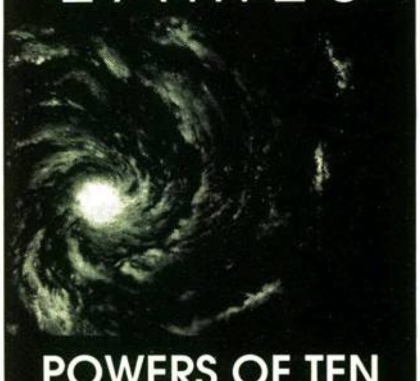

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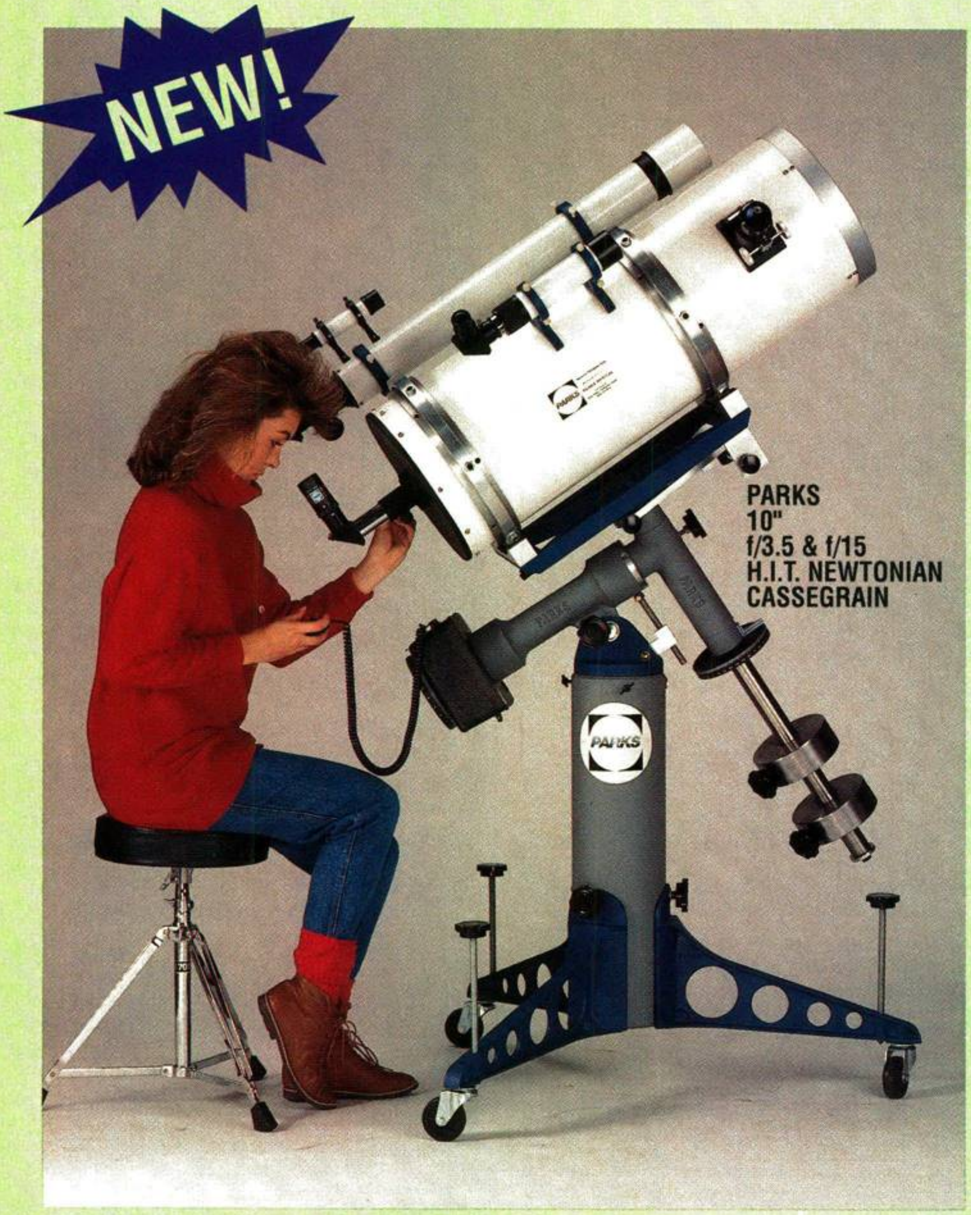

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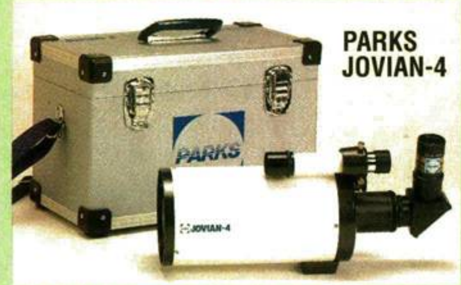

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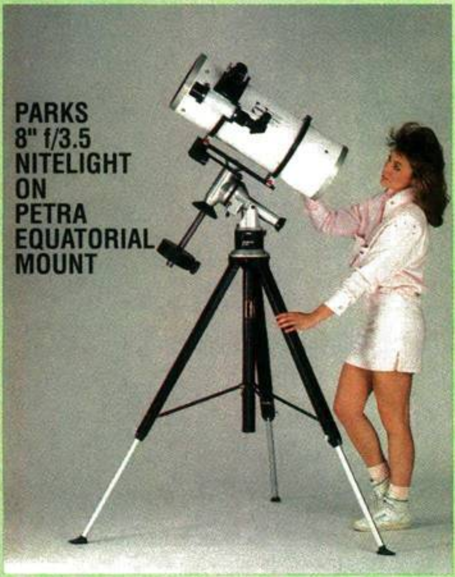

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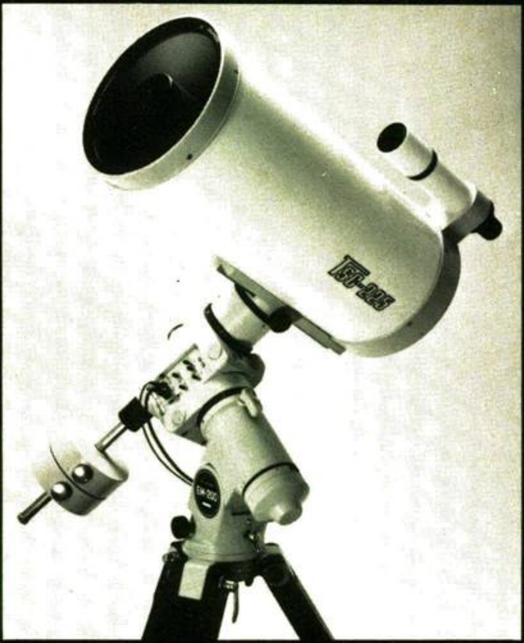

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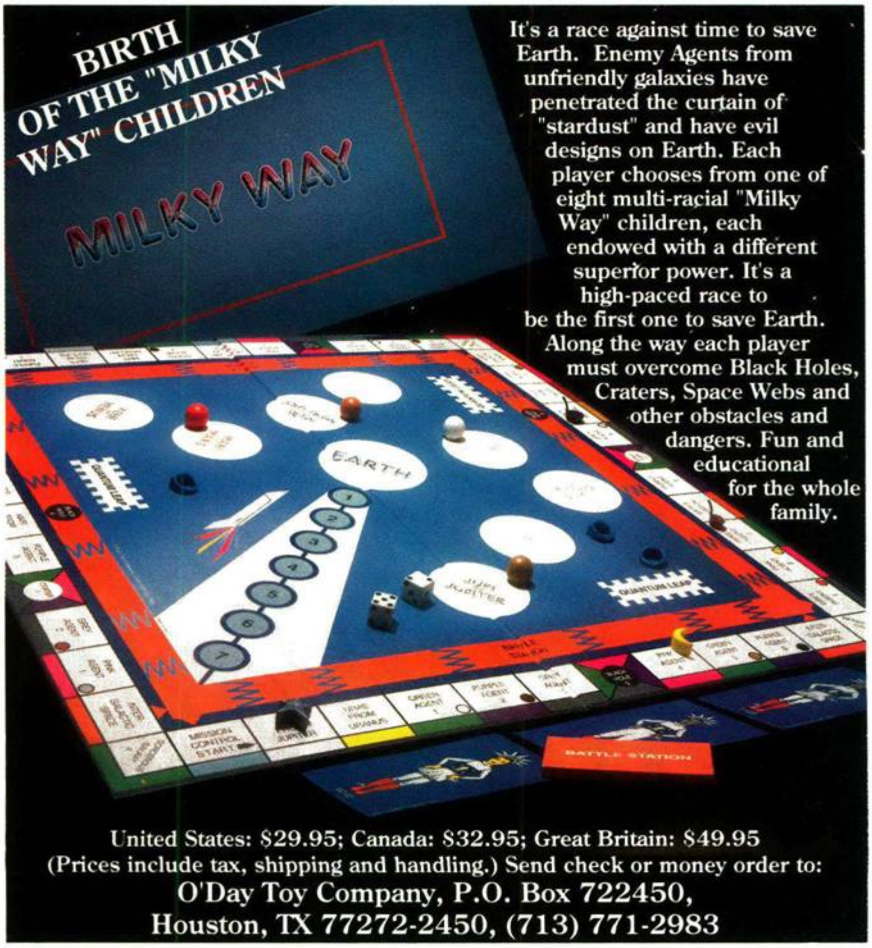

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Viewpoints

MARTIANS

by Erik Berg

"Clear cool night. Slight wind, but very clear. 24-inch telescope. Mars. Syrtis Major is quite distinct, as is the northern polar cap. A haziness in the south; maybe a dust storm."

These words are on the 43rd page of my astronomical observation logbook. On the opposite side of the page is a nickel-sized pencil sketch of Mars, worn by constant erasing and redrawing as my hands mimicked the confusion of my eyes in their search for faint details. The sketch is one of a dozen I did that summer and just one of thousands done with this telescope over a century of study. In its small way my sketch is part of the legacy of Percival Lowell.

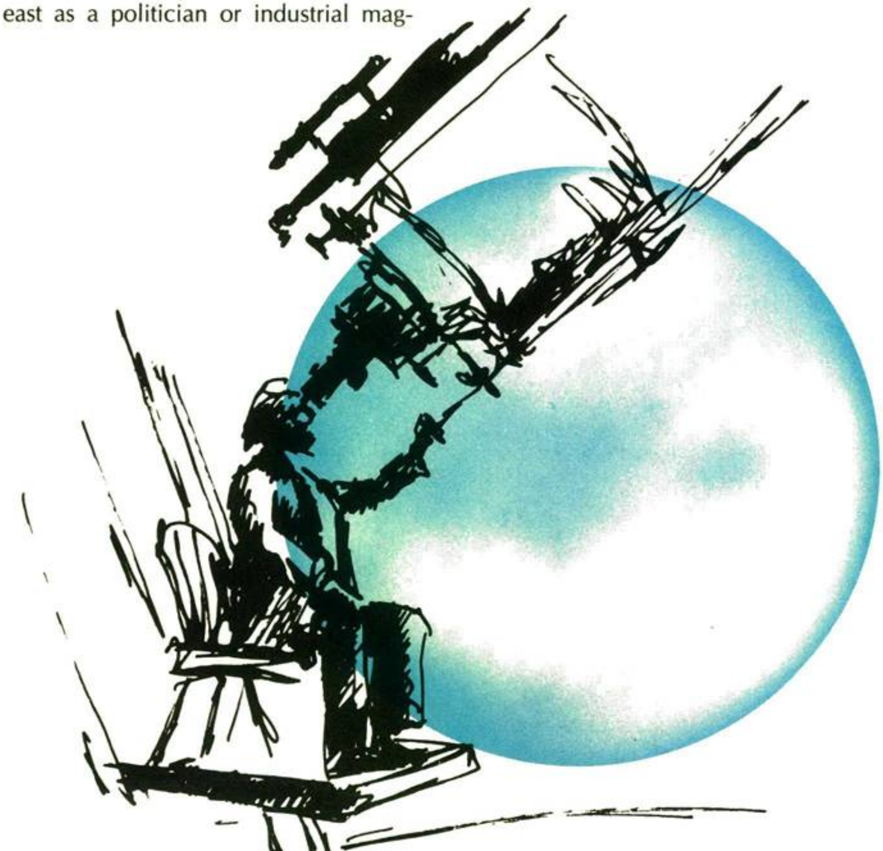
For the three summers that I worked as a tour guide at Lowell Observatory, his frowning countenance greeted me each morning as I unlocked the heavy wooden doors of the visitors' center. A full-length portrait of Lowell, done sometime in his fifties, stands solemn guard over the room from its post above the fireplace. He is wearing an expensive brown overcoat which sits taut on his rigid frame like a suit of armor and his right hand wields a cane like a sword. His mouth, firm and serious, is a straight crease below an even straighter nose, and his pale eyes, outlined in circles as an owl's are, stare beyond the viewer, beyond the Earth. In this manner the leading proponent of life on Mars and the champion of the canals continues to greet visitors in the main hall of his observatory overlooking Flagstaff, Arizona.

More often called the Rotunda, the visitors' center is a large round room with a high-domed ceiling designed by Lowell himself the year before his death in 1916. Suspended by heavy chains in the center of the room, a large stained-glass lamp in the shape of Saturn sends a pale orange light across the rows of displays and old, hand-drawn globes of Mars. At the same height as the lamp, a wooden catwalk, reached at either end by a pair of spiral stairs, gives access to the shelves of old books and manuals that remain from the time when this room was the observatory's library.

My duties included operating the telescope on public nights, answering phone calls, and cataloging the nearly endless piles of old photographic plates. But on most days, I simply watched over the Rotunda, answering questions and giving tours twice a day. Sometimes there would be huge crowds: tired and anxious tourists scoring one more point in their scavenger hunt of local attractions, astronomy buffs making a pilgrimage from the East Coast or Europe, and people who simply took a wrong turn while trying to find the road to the Grand Canyon. At other times, especially in the late afternoon or on rainy days, the Rotunda remained empty for hours. Then I would busy myself with paperwork, browse through the books, or simply sit and contemplate the portrait of Lowell or his globes depicting the famous canals of Mars.

To me, Lowell, like the planets he studied, seemed distant and unreachable, yet filled with some fantastic secret or ominous truth. Born in 1855 to a rich Boston family and graduating with honors from Harvard with a degree in mathematics, Lowell had a future full of potential. Like many of the social elite of his time, he spent his younger years managing the family business (textiles) and traveling, especially in the Orient. In the descriptions of his travels as well as in his business transactions, Lowell maintained the conservative, methodical attitude expected from his upbringing and education. He appeared headed for a respectable career in the east as a politician or industrial magnate, perhaps even an educator. Yet in 1894 Lowell abandoned his Boston comforts to found an astronomical observatory in the rugged mountains of northern Arizona. After two years of observations Lowell proclaimed to the world that he had found irrefutable proof of life on Mars, a claim which ignited one of the most sensational controversies in the history of astronomy.

What amazed me most about Lowell was not that he believed in such a fantastic idea as life on Mars; other respectable scientists of the time held similar ideas. Rather it was the *passion* with which he pursued his theory that enticed me. Percival Lowell was known to most of his associates as a distant, impersonal, even aloof businessman and mathematician who looked down on excessive emotion. He married, late in life, a long-time Bostonian neighbor and never had any children. The letters of his which remain today are filled with technical reports and factual observations untainted by emotional insights. Yet when it came to discussing Mars and its inhabitants, Lowell was driven, impassioned. As he wrote in his book *Mars and its Canals* (1906), "The less the life there proves a counterpart of our earthly state of things, the more it fires fancy and piques inquiry as to what it be."



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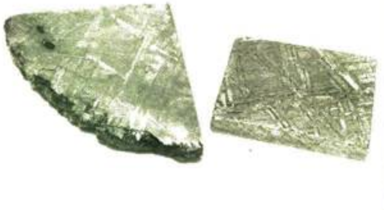

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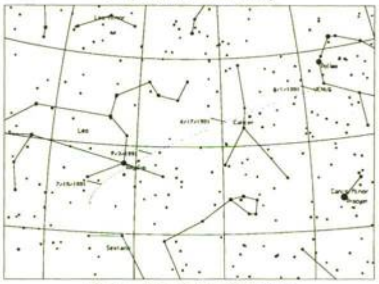

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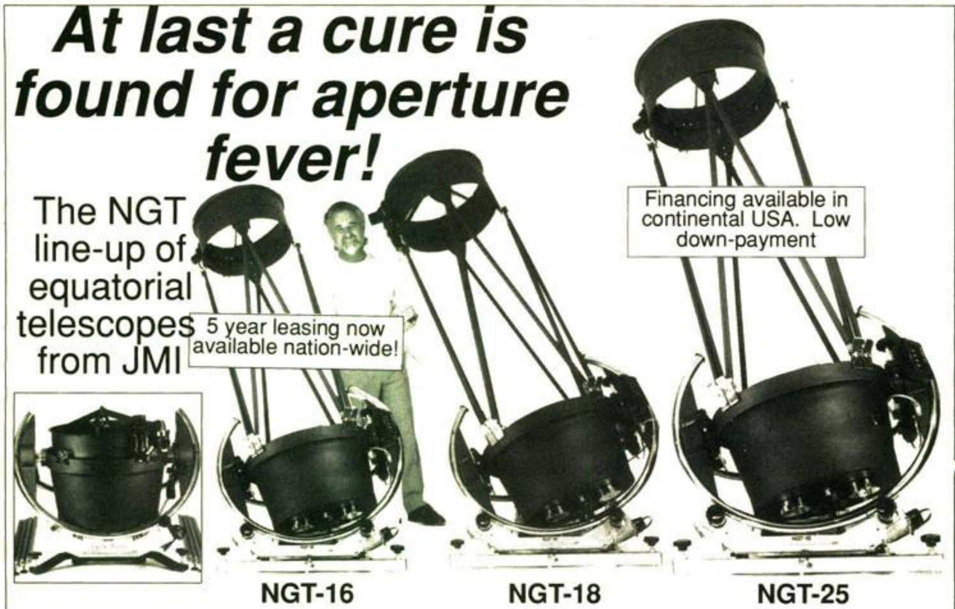

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NGC1300 - NGT-18 f/4.5
25 min. hypered 2415.

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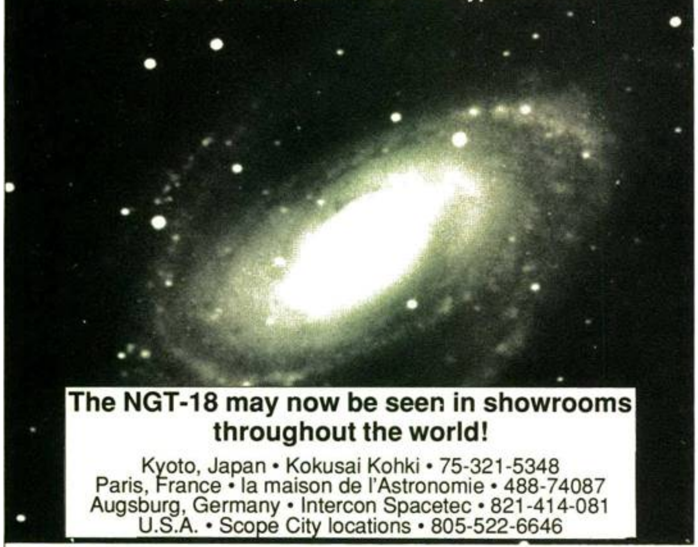
M81 - NGT-18 f/4.5, 30 minutes on hypered 2415.



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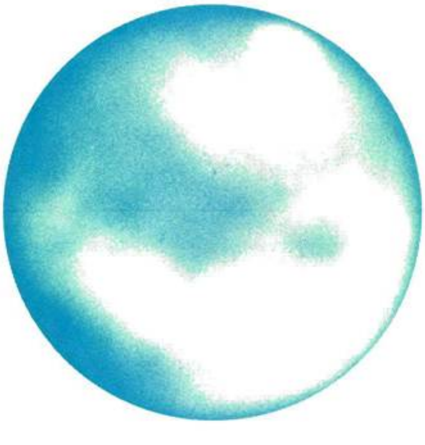
On a rise a short distance from the main building is the old white wooden dome housing Lowell's original telescope. Inside, the instrument stands largely unchanged from the time of its construction nearly a hundred years ago. One of the last great refractors built by the company of Alvan Clark and Sons, it is a thirty-foot-long cylinder of cast iron, crossed with rivets, and covered in wheels, rods, and dials. When you first see it at night, towering in the center of the dome, outlined against the stars and faintly glowing in a reddish light, you have an impression of overwhelming power and of precision. On one side of the dome sits a wooden viewing platform, creaky with age. This is where Lowell sat as he observed Mars for hours at a time, making sketches, pondering alien landscapes. This is where he saw those faint lines on the planet's surface, the Martian canals that could only be the product of an intelligent race.

I have spent many nights here after the crowds have gone home, flipping through star charts, making sketches, or hunting for comets. Despite its great age, the Clark refractor remains a fine performer and on clear nights the effect is almost magical. The clarity of the images pulls at your eye, drawing the focus of your thoughts, your soul even, into the most distant corners of space. At 50 million miles, the dark outline of Syrtis Major lies across the face of Mars like a pirate's eye patch. Twenty million light-years farther away, the nebulous arms of the galaxy M51 wrap together in an ever-churning whirlpool. Farther still toward the edge of the universe, quasar 3C 273 shines feebly like a beacon on the edge of time. And if you look even farther, into the empty darkness between the stars, the planets, and the galaxies, you can see into infinity.

To an astronomer working alone in the darkness, the quiet of night, the shimmering of faint details in the telescope, and the sudden awareness of the vastness and emptiness of space can be overwhelming — horrifying and yet enticing. Lowell often described this sense of isolation and vertigo as being almost religious in nature, a penance paid for truth. "Astronomy now demands the bodily abstraction of its devotee. Its deities are gods that veil themselves amid the man-crowded marts and impose withdrawal and seclusion for the prosecution of their cult."

Often while studying the planets, I have become so deeply engrossed that all my senses are focused on that single beam of light streaming from the eyepiece. For a brief moment there is nothing but the dust storms sweeping across Mars or the churning atmosphere of Jupiter — and I am there, a mere human underfoot in the house of the gods. When I step away from the eyepiece, it's like waking from a dream, as the familiar shapes of my own small world close around me. Those moments of revelation are exhilarating and yet terrifying. I want to force the images of Mars, of Jupiter, of the heavens back into cardboard cutouts on a classroom wall, into something friendly or at least human. It is at times like these that I too have seen the faint lines, like letters drawn by a fine pen, fading in and out of existence amid the features of Mars. Usually, I step outside the dome onto the small porch and stare down at the lights of Flagstaff, listening to the reassuring sounds of car horns and railroad trains.



Seventy-five years after his death, the spirit of Percival Lowell continues to haunt our dreams. Toward the end of my last summer, on a rainy August day when the Rotunda was empty, a small gray-haired old man dressed in overalls and a tattered overcoat walked into the visitors' center clutching a crumpled sheet of paper against his chest.

"What do you fellahs know about that wreck on the Moon?" he asked in a hushed tone. Then without waiting for a reply, he continued, "This astronomer fellah told me all about it, even gave me this map. Says that on this one Apollo photo you can see this wrecked spacecraft, plain as can be."

With that he laid his crumpled piece of paper on the desk and shoved it toward me. It was indeed a map, hastily drawn with a pen on lined paper showing a collection of small craters. The ink had faded and run in places, and the edges were smudged and worn by sweat and fingerprints. But the words "alien wreck" could still be seen next to a strange oblong feature lying on a crater floor.

As I handed the map back to the man, I explained to him that I myself had never noticed any alien wrecks on that part of the Moon before, but that I would gladly check the Apollo photographs for him. He gave me a quick nod, then sat down anxiously on a nearby chair and for the first time stopped to look around the room.

When I returned a short time later with the Apollo collection, he leaped up from his seat, and as I searched for the appropriate shot, he stood beside me wringing his hands and smiling like a pirate about to unearth a treasure chest.

Finally, I located the appropriate photo. Much to my surprise the man's map was an accurate depiction of the Apollo shot — with one exception. Where the map said "wreck," the photo showed only the blank surface of a crater floor. Instantly, all the light and energy faded from the old man's face. He quickly folded up his map and buried it in his coat pocket.

For a few minutes, we talked about the weather, about astronomy, about the observatory. Then he thanked me for my help, shook my hand, and walked slowly to the door. As he pulled the door shut, I heard him quietly say to himself, "Well, maybe they fixed them photos."

I nodded in agreement, although by now he had already disappeared into the rain, another soul haunted by Lowell's legacy. I had never seen him before, and I never saw him again.

Until the end of his life, Percival Lowell firmly believed that Mars was inhabited. Amid the graceful waterways and cities of the Martians, he was able to find an escape from our world and a defense against the emptiness that surrounds it. Today there is no life on Mars and the canals are simply illusions. Lowell's theories are laughed at — the product of a romantic age, the result of an old gentleman's eccentric imagination.

Yet who has ever looked into the stars without wondering, even hoping, that something more than just empty space and burning hydrogen surrounds us. I wonder if it's possible for a entire planet to feel lonely. ☐

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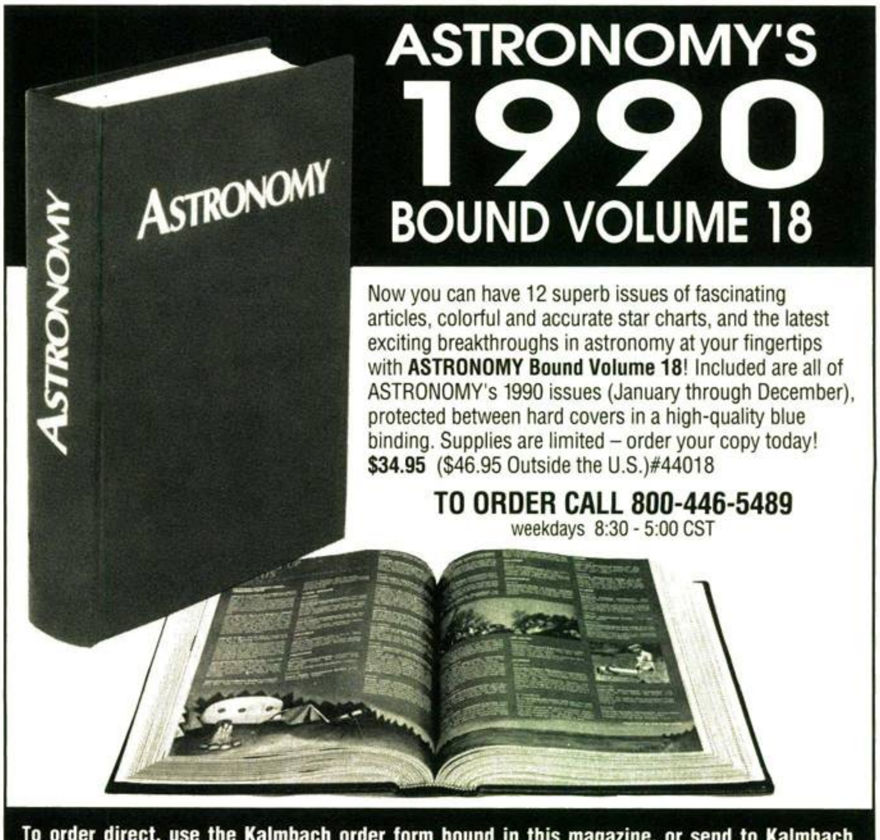

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ASTROPHOTO OF THE MONTH

Galaxies NGC 4631 (left) **and NGC 4656/7** (right) **in Canes Venatici.** 50 minute exposure by Martin Germano using 2415 hypered in a LUMICON Hyper-Kit and an 8" f/5 telescope with a LUMICON 2" Newtonian Easy-Guider. Much detail can be seen in 9th magnitude NGC 4631. Look for nearby 12th magnitude NGC 4627. NGC 4656/7 has an interesting hook; look for the hard-to-see faint extension doubling its length.

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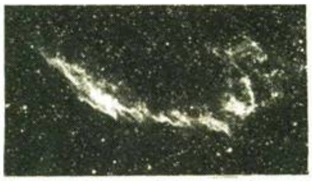

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- 205 best colored & multiple stars
- Displays Uranometria 2000.0 chart no.
- ROM upgradable for planets, extended object lists, etc.
- TIMER function, elapsed time & stop watch
- 2 star alignment for alt-azimuth or equatorial telescope systems
- 1 star alignment if polar aligned
- Uses Epoch 2000.0 coordinates
- May align on any of the 1500 objects in memory

COMA CORRECTOR

Coma 1 inch off-axis 17½" f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2" lens reduces coma and flattens the field for both viewing and photography. It threads into LUMICON 2" EASY-GUIDERS for effortless installation. This lens is optimized for f/4.5 and reduces aberrations for f/3.5 to f/5 Newtonians. Off-axis images are much smaller, making off-axis guiding far easier and yielding round pinpoint star images in photos. Since star images are sharp over a full 2¼" circle, you can use medium format cameras in addition to 35mm cameras. This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Although designed for photography you may also use this lens to improve image quality in wide-field viewing with low power eyepieces. Clear aperture = 1.8".

LUMICON Coma Corrector/Field Flattener Lens	**$285.00**
LUMICON 2" EASY-GUIDER	**$169.50**
2" EASY-GUIDER (Mamiya 645)	**$199.50**
2" Adapter for Pentax 6x7	**$85.00**
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Options Enhance Performance

Super Wedge for 10"	**Add $299**
ECC Electronic Command Center	**$275**
#39 Declination motor	**Add $109**
Digital setting circle	**Add $399**
2" Star diagonal	**Add $179**
LUMICON Cassegrain Easy-Guider *(Please specify camera)*	**Add $225**
LUMICON Giant Easy-Guider (for #40) *(Specify camera)*	**Add $395**
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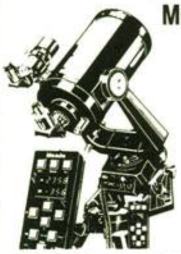

Meade Premier 2080 Model 50SD

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Ultra Wide-angle: 4.7mm **$149,** 6.7mm **$179,** 8.8mm **$209,** 14mm **$249**

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1.8x Multiplier Lens

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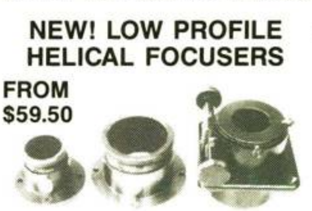

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2" adapter for C-80, C-100 refractor	**$39.50**
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2" LUMICON EASY-GUIDER (state camera)	**$169.50**

ADAPTING TO THE FUTURE

When more than 1,000 members of the American Astronomical Society met in Seattle from May 26-30, 1991, they announced a wide range of interesting news. Among the most noteworthy developments were a method to improve ground-based telescopes, an intriguing hypothesis suggesting that 10,000 planets exist in the far reaches of the solar system, a simplified and coherent model for the behavior and evolution of quasars and active galaxies, and the first resolution of individual stars in a galaxy in the distant Virgo Cluster. What follows are brief reports on the Seattle meeting's top developments.

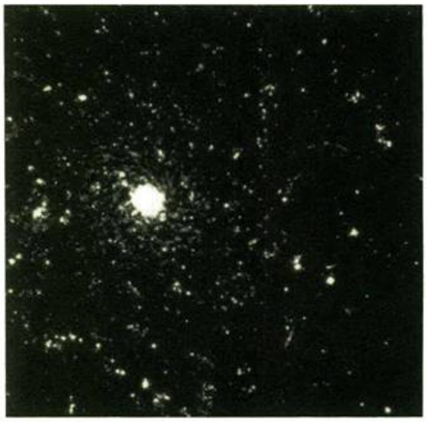
The Revolution in Optics. Adaptive optics, a method to reduce the effects of Earth's atmosphere on star images, will forever change ground-based astronomy. Developed for military use and declassified by the Pentagon in mid-May, the technique will allow astronomers to effectively subtract the blurring effects of the atmosphere from their observations. "When this technique is up and running, ground-based imaging will be equal to or even better than a repaired Hubble Space Telescope," says Charles H. Townes of the University of California at Berkeley. Adaptive optics works in a complex yet absolutely reliable way: the telescope operator fires a laser beam into sodium atoms high in the atmosphere, which bounce the laser light back into an array of electronics in the observatory. By using a computer to observe the effects of the atmosphere on the laser light, as many as thirty times per second, astronomers can apply corrections on the telescopic image, canceling the blurring effects of atmospheric turbulence. Aside from achieving superb resolution, astronomers will gain a dramatic increase in the intensity of images, meaning that shorter exposures are needed.

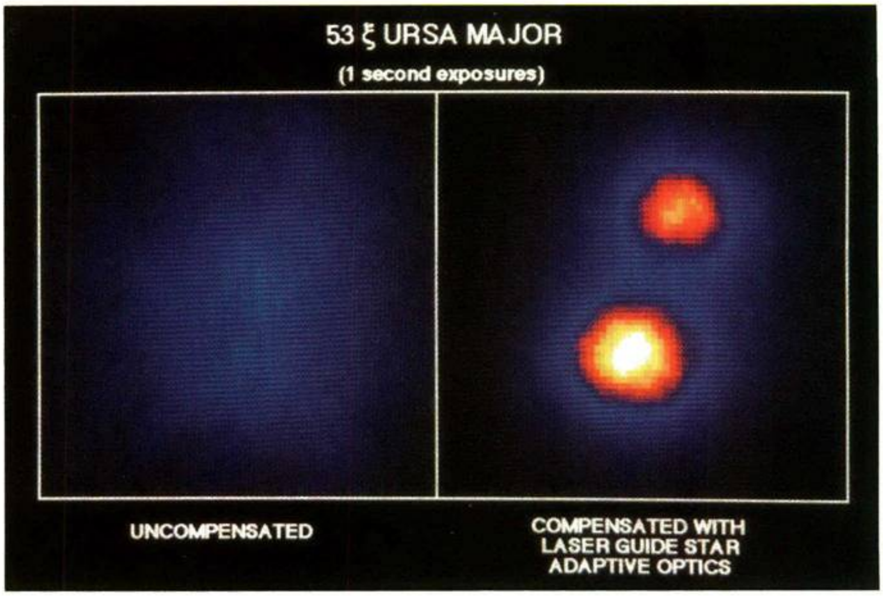
The theory of adaptive optics has been around for quite some time. But implementing the technique has been a difficult task for physicists and opticians. In 1988 scientists at the Massachusetts Institute of Technology's Lincoln Laboratory perfected the method of using a small "mirror" — actually a reflectively coated, thin rubber membrane — to divert the image into the electronics unit. The mirror assembly contains a set of push-pull actuators that deforms the mirror. The actuators allow the astronomers to correct for the atmosphere by warping the rubber mirror into constantly changing shapes that cancel the blur of bad seeing.

The technique is especially powerful with infrared telescopes, but is rapidly gaining in its effectiveness for visible light observations. "We will see adaptive optics fully developed within the next decade," predicts Townes, "and it will revolutionize astronomy from the ground."

Early Results from ASTRO-1. Astronomers at NASA's Goddard Space Flight Center — home to research from the ASTRO-1 mission — deluged their colleagues with results from the week-long shuttle mission that occurred in December 1990. (These results followed by one week the announcement that the ASTRO observatory will fly again in late 1993 or early 1994.)

The observatory's four instruments proved themselves workhorses of ultraviolet and x-ray astronomy. "BBXRT is giving us a clearer picture of BL Lacertae objects, Seyfert galaxies, supernova 1987A, galaxy clusters, and many other high-energy objects," says Goddard's Keith Jahoda. BBXRT, which stands for Broad Band X-Ray Telescope, made one observation of just 1,000 seconds that accurately showed the distance to





ADAPTIVE OPTICS is a new technique that promises to revolutionize ground-based astronomy by deforming optics to subtract the blurring effects of Earth's atmosphere. A "before and after" photo of the star Xi Ursae Majoris shows a straight image (left) and an improved image using adaptive optics. Photo courtesy Charles H. Townes, University of California.

During the same week the technique was declassified by the U.S. military, astronomers at the Dominion Astrophysical Observatory in Canada announced they had used adaptive optics on Mauna Kea's Canada-France-Hawaii telescope to resolve individual stars in NGC 4571, a galaxy in the Virgo Cluster (top). Such resolution is unprecedented in ground-based astronomy, and will enable astronomers to accurately determine the distance scale of the universe. Photo courtesy DAO/National Research Council of Canada.

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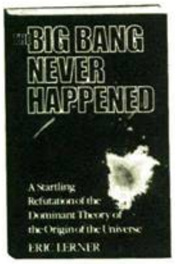
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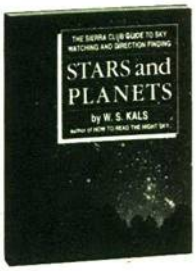
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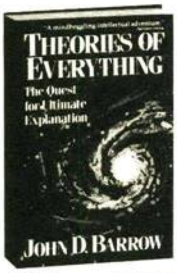
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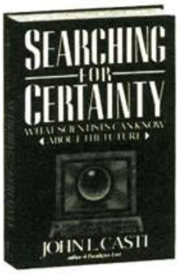
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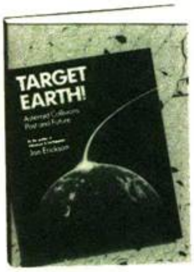
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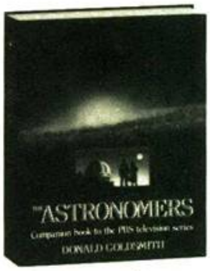
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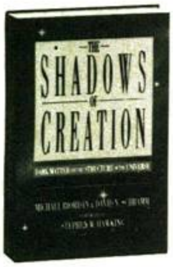
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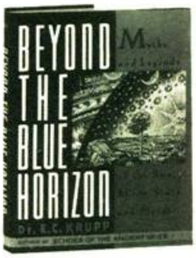
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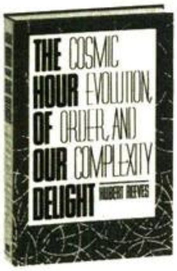
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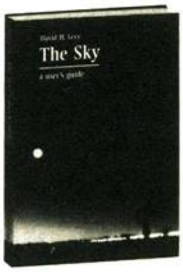
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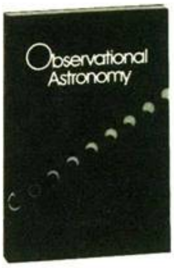
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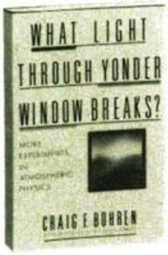
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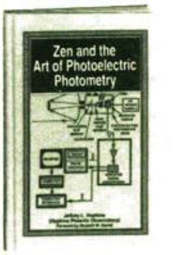
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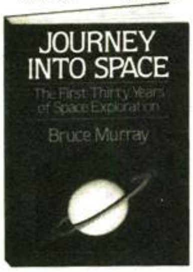
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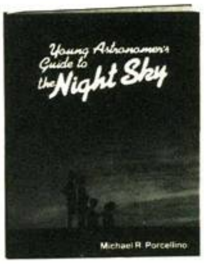
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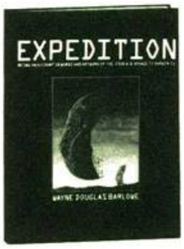
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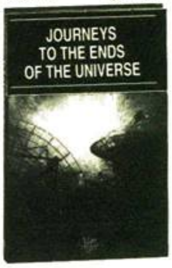
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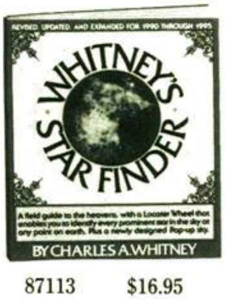
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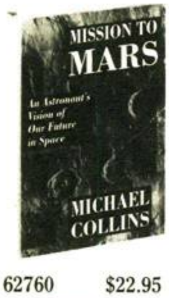
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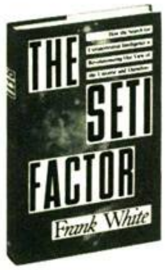
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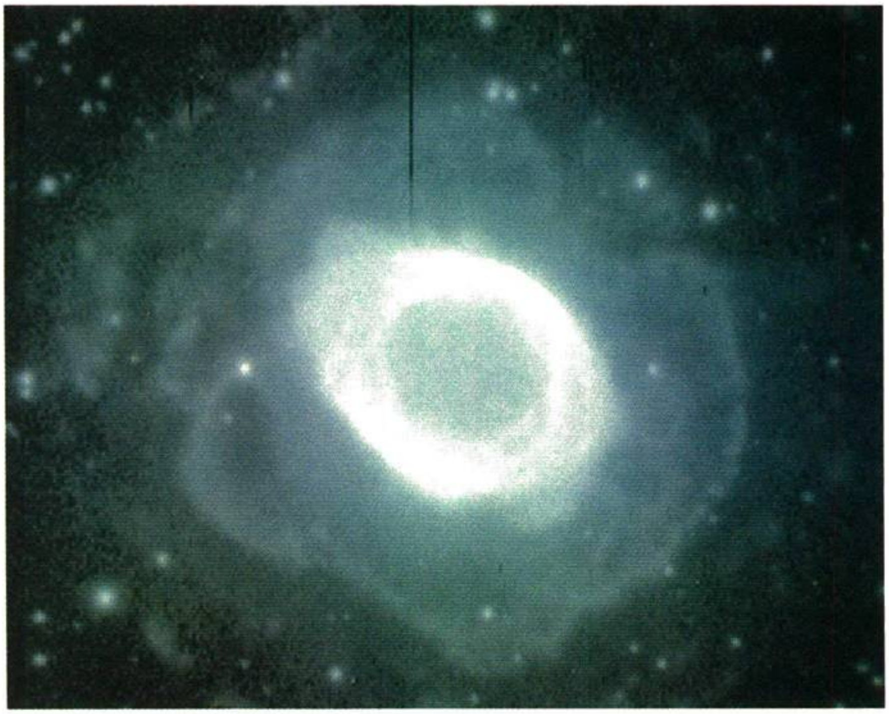
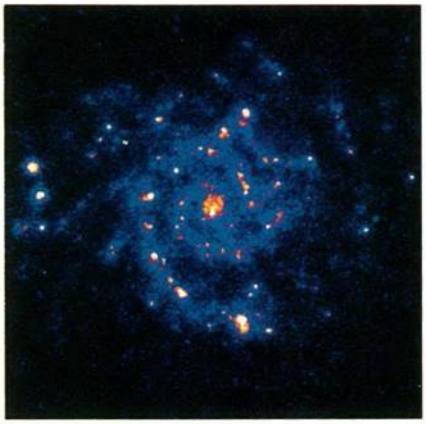


ARE PLANETARY NEBULAE HEAVYWEIGHTS? Astronomers now believe giant shells of molecular hydrogen gas surround the bright optical parts of planetary nebulae. The previously unknown dark shells are thought to contain as much as ten times the mass of the bright part of the nebula. Interaction between the dark shell and the expanding bright cloud explains the odd shapes of the bright outer envelopes observed in nebulae like M57 (above). Photo courtesy Bruce Balick, University of Washington, and George Jacoby, Kitt Peak National Observatory.



GLOWING REGIONS OF STAR FORMATION pepper the spiral arms of galaxy M74 in this image made in ultraviolet light during the ASTRO-1 mission in December 1990. The week-long shuttle observing session produced dozens of similar images made with the Ultraviolet Imaging Telescope and large amounts of data from three other ultraviolet and x-ray instruments. Photo courtesy NASA/Goddard Space Flight Center.

the Perseus Cluster of galaxies is 350 million light-years, a distance astronomers have been trying to pin down for many years.

"The Hopkins Ultraviolet Telescope is showing us how to map the local interstellar medium," declares Randy Kimble of Johns Hopkins University. "HUT has provided us with the first direct measurement of interstellar helium. It has allowed us to draw broad conclusions about the region of space that surrounds us." Kimble explains, "Our solar system is surrounded by a cloudlet of cool hydrogen about 10 light-years in diameter. That, in turn, is enveloped by a larger, oval bubble of warm hydrogen that is perpendicular to the galactic plane." HUT has also uncovered its share of mysteries, including the observation that the larger cloud of local hydrogen is substantially ionized. "There's currently no mechanism to explain this," says Kimble, "but it's possibly due to decaying neutrinos or a relatively recent and nearby supernova."

Karen S. Bjorkman of the University of Wisconsin outlined research with the Wisconsin Ultraviolet Photo-Polarimeter Experiment (WUPPE). "We've scored one for the observers and zero for the theorists," Bjorkman says as she explains that her research on Be stars demonstrates how these hot, rapidly rotating suns polarize light. "The polarization does not rise in ultraviolet light, as the theorists suspected," remarks Bjorkman. "This is going to tell us a lot about what stars are made of and how stars lose mass."

"The Ultraviolet Imaging Telescope produced approximately 1,000 times as much data as any of the other instruments," beams Robert W. O'Connell of the University of Virginia. "UIT results form the core of 21 research papers at this very conference." The success of the UIT is evident in its false-color ultraviolet images. Early results from the telescope include an ultraviolet view of the galaxy M74 with bright knots of star formation scattered through its spiral arms, a view of the star-forming region 30 Doradus in the Large Magellanic Cloud, and an image of the Crab Nebula.

Where Did All the Tritons Go? "Something's not quite right in the outer solar system," according to Alan Stern of the University of Colorado. Reporting on a paper published in the April 1991 issue of *Icarus*, Stern suggests that certain characteristics of bodies in the outer solar system — the existence of the Pluto-Charon binary planet system, the tipped rotational axis of Uranus, and the retrograde orbit of Neptune's large moon Triton — would have required a substantial population of small, rocky bodies to have occurred in the early solar system.

Stern proposes that as many as 10,000 proto-planets with diameters of perhaps 1,000 kilometers each did exist in the early solar system and ultimately flew out of the solar system to the Kuiper belt and the Oort cloud. "Pluto, Charon, and Triton are relics from this old class of planets," suggests Stern. "Perhaps we will be able to image these remote planetary cousins when the Space Infrared Telescope Facility is launched toward the turn of the century."

Zombie Quasars. S. George Djorgovski of the California Institute of Technology has announced a "unified quasar theory." One of the most perplexing problems facing extragalactic astronomers today is sorting out the baffling array of high-energy galaxies with "central engines" — BL Lacertae objects, radio galaxies, quasars, Seyfert galaxies and so on. Djorgovski has proposed that these seemingly disparate objects are the same objects viewed from different angles and at different evolutionary stages.

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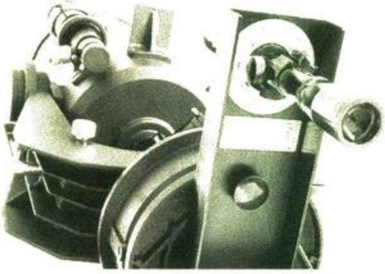

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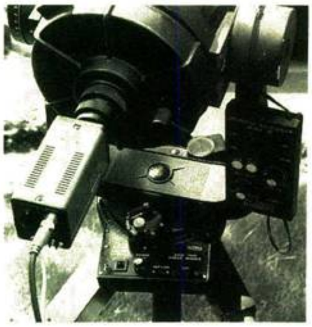

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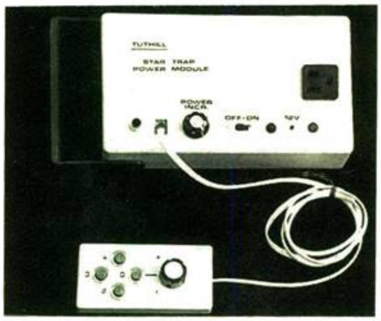

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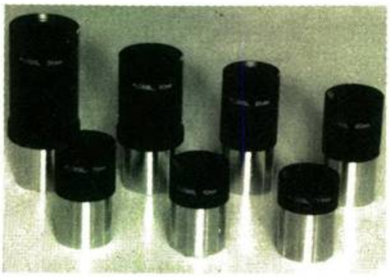

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"My research shows the central region of the radio galaxy Cygnus A contains a torus of molecular dust 10 to 1,000 light-years thick," says Andrew S. Wilson of the University of Maryland. "The torus blocks the view of the galaxy's nucleus, so you see the narrow emission lines only." Djorgovski believes the effect applies to galaxies everywhere in the universe. "The angle of view makes the determination," remarks Djorgovski. "Either you are blocked by dust and see a powerful radio galaxy or look straight down the barrel to see a naked quasar." Djorgovski casually dubs the hidden quasars "buried quasars" or "zombie quasars," and believes they are commonplace in high-energy galaxies.

A New View of Planetary Nebulae. Planetary nebulae are those bright disks that are so easy to see in small telescopes, right? Wrong. Discoveries by a team of galactic astronomers now show that planetary nebulae harbor immense shells of molecular gas that are invisible to the eye, and that planetary nebulae are therefore far more massive than previously suspected. The University of Washington's Bruce Balick has been imaging planetary nebulae for several years now. "For more than 100 years we've thought that with planetary nebulae, what you see is what you get," says Balick. "Now we see that most of the material in a planetary nebula is unseen in visible light."

Planetary nebulae form when red giant stars exhaust their nuclear fires and puff off shells of gas. "We now know that a molecular cloud forms before the visible nebula, late in the life of the red giant," says Patrick J. Huggins of New York University. "The molecular cloud moves out slowly and may represent 10 times the mass of the glowing nebula that forms later. Several thousand years after the molecular shell forms, the star begins a series of pulsations and throws off the glowing gas in a series of events timed a few thousand years apart. The bright gas moves out at high velocities and interacts with the slower, dark gas."

According to Balick, "the stellar wind sculpts the molecular cloud and we now understand why we see many unusual and intricate shapes in the outer envelopes of planetaries. It's humbling work, however, because we realize that one day Earth will lie immersed in a pool of warm molecular material. It'll be worse than Washington, D.C. in August!"

BATSE's Numerous Gamma-Ray Bursters. One of four instruments on NASA's Gamma Ray Observatory is dubbed BATSE, the Burst and Transient Source Experiment. Consisting of eight detectors mounted on the corners of the spacecraft, BATSE's detectors constantly watch for bursts of gamma-ray energy. When they detect a signal, triangulation between the detectors allows the scientists to fix the location of the source to within a few degrees in the sky.

"The problem is that we're flooded with data," says Gerald Fishman of NASA's Marshall Space Flight Center. "BATSE is detecting much higher numbers of gamma-ray bursts than have ever been observed. We've recorded 31 bursts in 35 days of observation, for example, whereas the previous record was 80 bursts per year."

The origin of these gamma-ray bursts is, to put it mildly, very much in question. From BATSE's observations astronomers know that the events are unique and not repeating from the same source, but they do not yet have

Amateur News

PERFECT SKIES IN TEXAS

More than five hundred observers gathered in Fort Davis, Texas, from May 12-19, 1991, for the tenth annual Texas Star Party. As always, the event took place on the Prude Ranch, a working dude ranch located 10 miles from McDonald Observatory and three miles from the town of Fort Davis. Although the temperature was high and the landscape dusty, everyone who attended enjoyed the dark skies overhead.

The highlight was a week-long stretch of clear weather that left observers exhausted by mid-week. Nonetheless, the attendees — mainly from the southwest but some from as far away as England — stayed up nightly to use a battery of large telescopes scattered across the observing fields. Many telescopes in the 16-inch to 20-inch range were present, and a few telescopes of 25-inch diameter were on hand. Favorite objects included Omega Centauri, numerous deep-sky objects toward the galactic center, the gravitational lens object 0957+561, extraordinarily faint clusters of galaxies, and the supernovae in galaxies NGC 4527 and NGC 4902.

While a few diehards observed the solar disk during the day, most of the TSPers attended talks. Twenty-three talks highlighted a wide range of topics including the Soviets' exploration of Venus (Robert Reeves, San Antonio, Texas); CCD image acquisition (Dan Gordon, Reseda, California); methods used to find comets 1989a1 and 1991a (Howard Brewington, Cloudcroft, New Mexico); and observing the M81 galaxy group (Tom Polakis, Tempe, Arizona). Special talks included those by Pluto discoverer Clyde Tombaugh on his astronomical career; an explanation of the American Association of Variable Star Observers by Janet A. Mattei; a discussion of bright comets by John Bortle; and an exploration into the realm of galaxy-quasar pairs with discordant redshifts by Jack Sulentic.

Other activities included the judging of telescope making, an "observing olympics" in which several participants bagged a few hundred objects during the week, an astrophotography contest, the awarding of several Messier certificates from the Astronomical League, and two special awards. For her years of observing experience, the AAVSO's Janet Mattei won the Lone Stargazer award. For their years of service to the Texas Star Party, Houston's Steve and Amelia Goldberg won the Omega Centauri award. On several nights TSP astronomers talked with members of the Astronomical Society of New South Wales via shortwave radio and watched slow-scan television pictures between the two sites. To cap off the proceedings, the "Great Texas Giveaway" served up dozens of door prizes for lucky astronomers in the audience.

With an unimpeded run of dark skies in 1991, observers were already excited about the 1992 Texas Star Party. Next year's event will be held at the Prude Ranch from Sunday, April 26, through Saturday, May 2, 1992.

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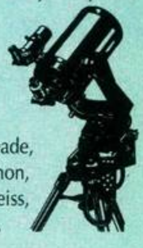

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For information on advertising in the Blue Sky Pages, call Cathy Odland or Greg Swan at (800) 558-1544 an accurate map showing the overall distribution of the bursts. The safe bet seems to be that most of the bursts originate in our Galaxy and are produced in binary systems where one star is a neutron star. If the bursters were as distant as other galaxies, they would have to be emitting unbelievably high amounts of energy. This is highly unlikely.

"We've now differentiated between types of gamma-ray bursts," says Fishman. "That's the major discovery so far, that some bursts are extremely short events of 1/10-second or less, others are relatively long — as much as 90 seconds. Still others start out at low energies and suddenly burst in a violent manner." Whereas most astronomers had believed until now that gamma-ray bursters are one type of object, Fishman now confidently claims "we're definitely dealing with more than one type of object and possibly more than one mechanism. Only more detailed measurements will allow us to sort it out."

The Most Distant Stars Yet Observed. Using the technique of adaptive optics (see p. 22), astronomers from the Dominion Astrophysical Observatory (DAO) in Canada announced they have resolved blue supergiant stars in a Virgo Cluster galaxy. The galaxy, NGC 4571, is a spiral that has been observed many times before. But the Canadian group, led by Robert D. McClure, used the Canada-France-Hawaii telescope on Mauna Kea to make the unprecedented observation.

The resulting image clearly shows individual stars in the galaxy's arms and is by far the most distant detection of normal stars to date. What's exciting about such a detection? "The Virgo Cluster is a cornerstone in establishing the distance scale of the universe," says Michael J. Pierce of the DAO. "Once we establish the distance to this cluster then the distance to everything else we can see falls into place. The observations of these stars is a great step forward in estimating just how far away more distant objects in the universe are."

The new estimate of the distance to NGC 4571 is based on the apparent brightnesses of these stars. "By comparing how bright the most luminous stars appear to be in this distant galaxy with similar stars of known distance in our Galaxy, we can estimate how far away the distant galaxy is." The Canadian estimate: approximately 50 million light-years.

These are but a few of the headline-making stories from this summer's AAS meeting. In next month's AstroNews we'll report on much more.

Space News

SPACE STATION SAVED, BUT AT WHAT COST?

The good news: Congress voted to restore funding for the Space Station. The bad news: Congress voted to restore funding! Depending on your space program loyalties, the decision was a triumph — or a disaster.

On June 6, the House of Representatives voted to restore $2 billion to NASA's 1992 budget earmarked for the Space Station Freedom, NASA's key project for manned spaceflight in the 1990s. The House decision overturned an earlier Appropriations Committee vote to cut all 1992 funding for the Space Station, a move that in the eyes of many space program supporters would have effectively axed the controversial Station for good.

As Lori Garver, Executive Director of the National Space Society told ASTRONOMY, "The House debate was the last realistic opportunity for cancellation of the Space Station. The favorable vote reaffirmed the U. S. position in space. Though the budget still has to go before the Senate, the Senate is much more supportive of the space program." Although the Space Station has been scaled down several times in recent years, Garver pointed out that the National Space Society "has continued to evaluate the design. We feel that the focus is still on life sciences, a mission the current station design should still accomplish." Proponents of the Station point out that this scientific goal will be an essential step toward eventual manned exploration of the planets.

However, for others the news was not so good. Louis Friedman of The Planetary Society called the Space Station approval "a giant step backward for the exploration of space. It set back the prospect for humans going to the planets by 10 to 15 years."

The reason for the criticism is that to get its $2 billion for the Space Station, NASA was told to find the money from other space projects. The single largest hit was to the Office of Space Science and Applications, the division of NASA responsible for orbiting observatories and planetary missions, among other missions. It is also the division with the second largest budget within NASA, next to the Office of Space Transportation. The Space Science budget was frozen at the 1991 level of $2.43 billion, requiring a cut of $500 million from the requested level for 1992. (The next largest cut was $200 million to Space Shuttle operations.)

To institute such a cut would mean sacrificing some space science missions, though the full impact won't be known until this autumn. Friedman suggested that the Comet Rendezvous and Asteroid Flyby probe might be the first to go. Other missions on the chopping block could include the Lunar Observer satellite, the Advanced X-Ray Astrophysics Facility (one of NASA's four "Great Observatories"), the Earth Observation System of remote sensing satellites, and the Cassini mission to Saturn.

According to Friedman, "We support a space station, but one that's good for science. As it is designed now, the Space Station serves no constituency — neither space science nor planetary exploration. It will only act as an albatross around our neck."

Though the various space lobby groups argue about the value of the Space Station, all agree that the current debate represents a critical point in the history of space exploration. Some funding could be reinstated for affected programs later this summer and fall as the debate reaches the Senate and its subcommittees. Admiral Richard Truly, chief NASA administrator, has vowed to fight to help reinstate some of the space science budget. Space advocacy groups such as the National Space Society and the Planetary Society are determined to do the same. □

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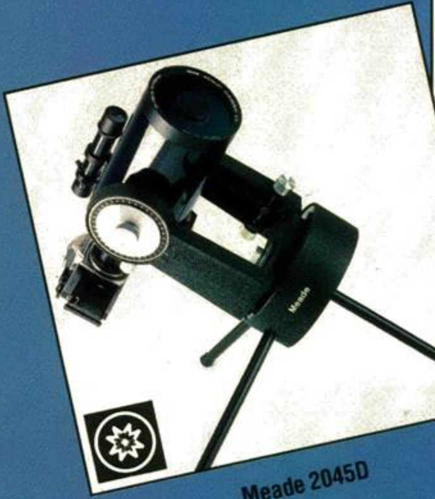

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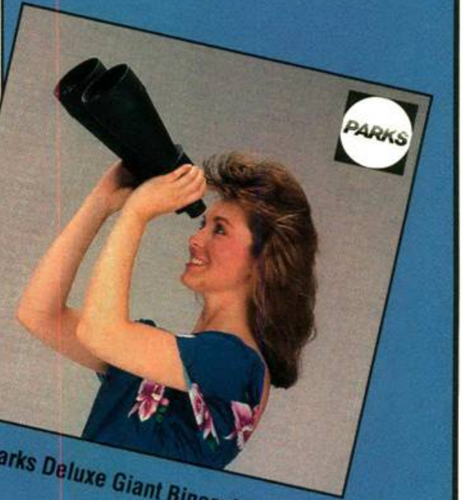

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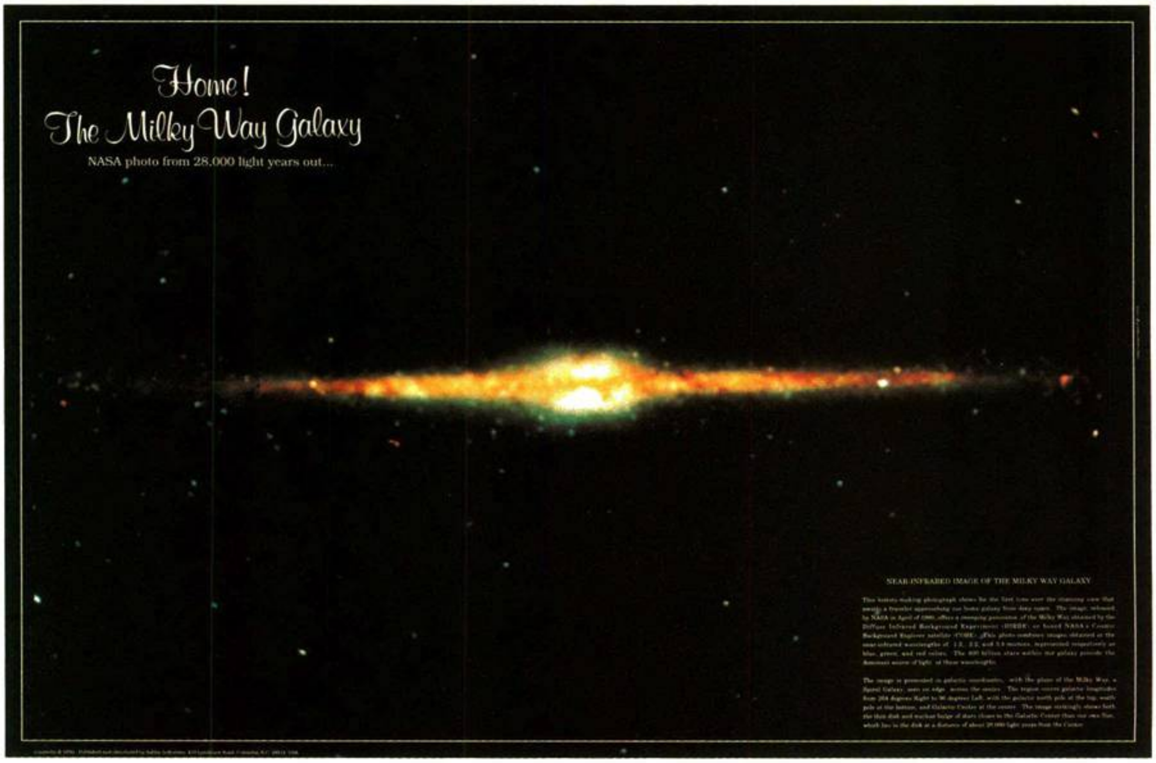
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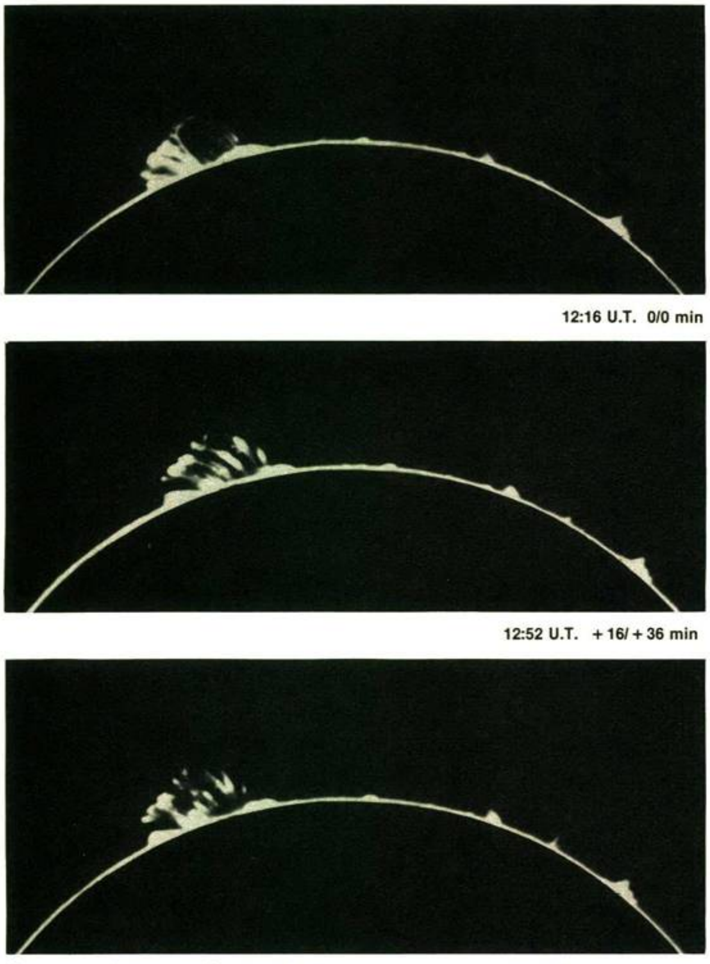

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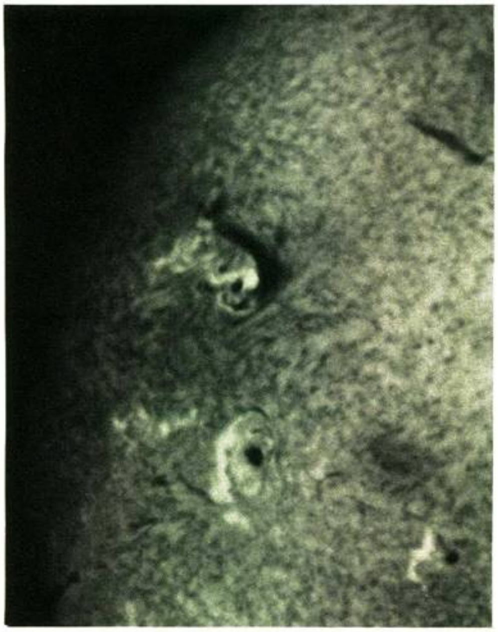
Our sun is the most amazing object in the sky any day you look at it. The ultimate observing experience is seeing a major solar eruption, a rarer and more scientifically significant event than an eclipse. But you have to be looking.

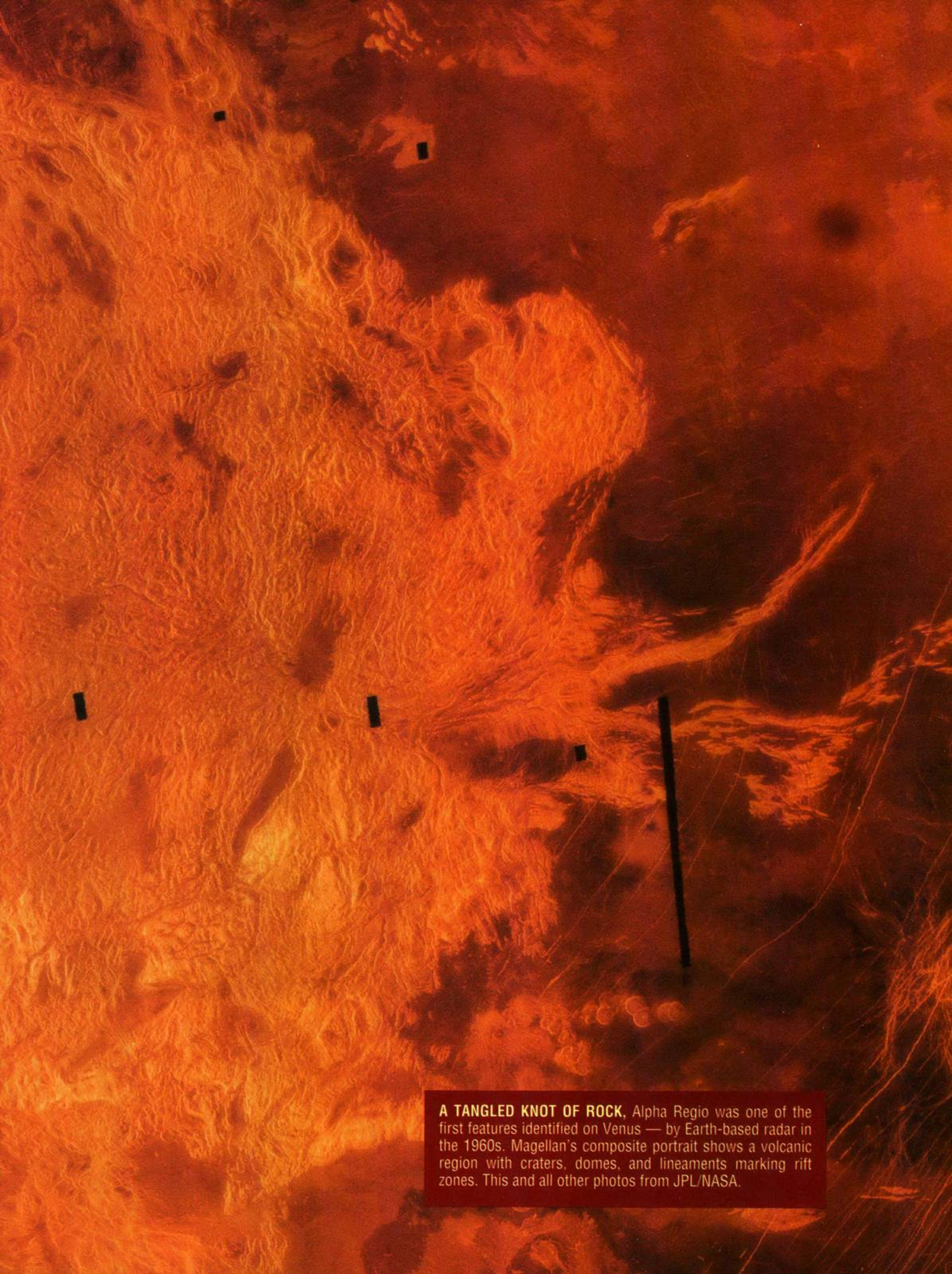


Solar flare with surge prominence.

Venus: Planet of Fire

Volcanoes, lava plains, and impact craters reveal in Venus a world that may resemble the early Earth.

by Robert Burnham



A TANGLED KNOT OF ROCK, Alpha Regio was one of the first features identified on Venus — by Earth-based radar in the 1960s. Magellan's composite portrait shows a volcanic region with craters, domes, and lineaments marking rift zones. This and all other photos from JPL/NASA.

Seventy-five kilometers below the dazzling white cloudtops of Venus lies a world of hot black rock. Bathed in a dim orange light, this world — covered with lava in nearly all its possible forms — stands as testimony to geological energies run wild.

To the green fields and hills of Earth, lava forms an exotic counterpoint. In only a few places does it dominate the scenery. Think of the bleakest part of Hawaii or Iceland, where the land is so new it's too hot to touch. Then imagine that the entire Earth — oceans, cities, fields, lakes, rivers, *every square inch* — looks as blackened as the wasteland in your mind's eye.

Welcome to Venus.

Magellan finished its first 8-month mapping cycle on May 15. As the craft's radar mapping continues into cycle 2, project scientists are poring over a still largely undigested mountain of data, looking for analogies with terrestrial features and trying to understand what the images show. Details abound, but explanations for them are in shorter supply. Venus has features that look completely familiar — and it has ones that are utterly unlike those here. An entire planet as big as Earth has suddenly been handed to planetary scientists in all its geological richness.

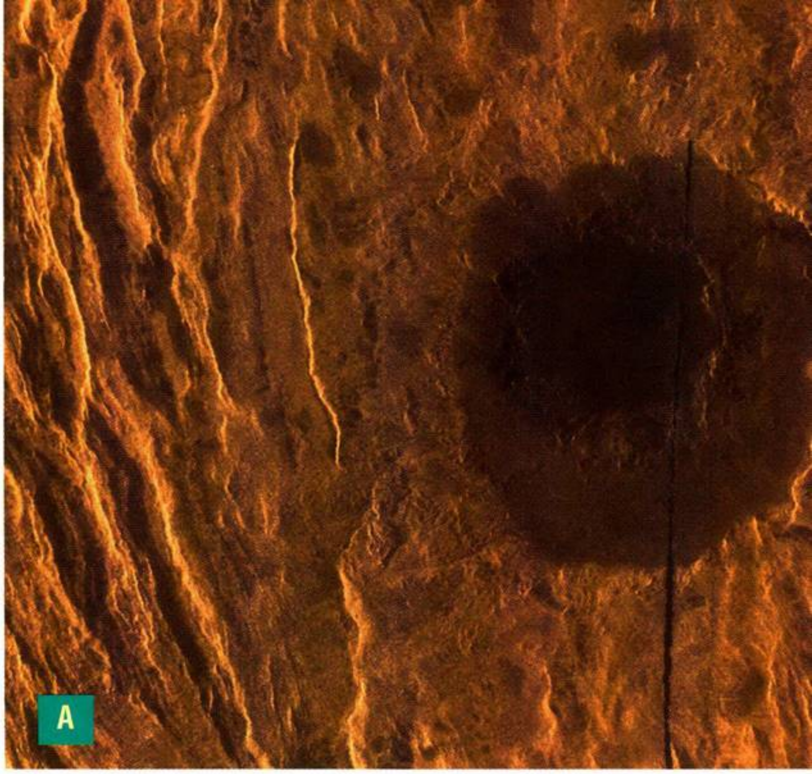
The Venus that is emerging from the data appears startlingly like a view into Earth's distant past. Not the sort of prehistory, replete with swamps and dinosaurs, that science fictioneers once loved to write about, but instead a vision of what our planet must have been like billions of years ago, perhaps before life ever began.

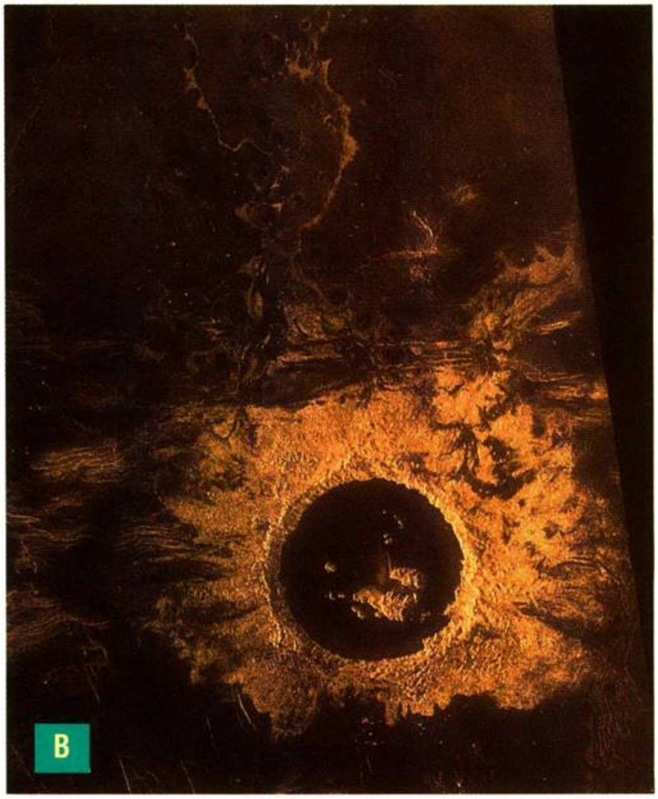
"Venus may resemble the Archaean Era on Earth," says Stephen Saunders, Magellan Project Scientist. The Archaean, a long-ago and little-understood period, lasted from the time the crust of the newborn Earth finally hardened until just after the emergence of life. It spans a time from about 4.5 billion years ago until 2.5 billion years ago, nearly half of our planet's entire history. But while the surface of Venus may look like an ancient Earth, it is actually relatively new. Scientists have found no Venusian features older than about a billion years, and most of the surface appears to be roughly 400 million years old. (This is older than the average age of Earth's surface, which is a few hundred million years, but much younger than the Moon, Mars, or Mercury, which have average surface ages of several billion years.)

Just how new is the Venusian surface? "We have not identified active eruptions," says Saunders. "But Beta Regio and eastern Aphrodite are two places we'll be examining very closely in the next mapping cycle as we look for changes." Any major outpouring of lava would show up on a second look and, according to project scientists, with a little luck and a special technique called three-pass interferometry three mapping cycles over the same area could detect elevation changes in the surface as small as a few centimeters.

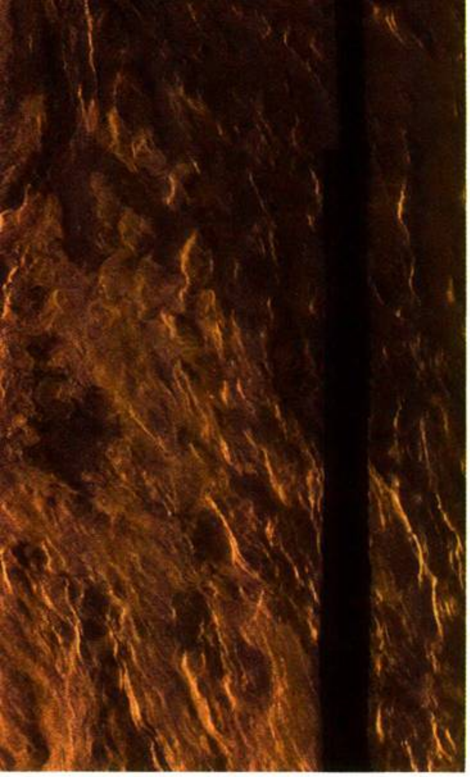
Craters: Clues to the Age of the Surface

The surface of Venus is fresh, but assigning dates

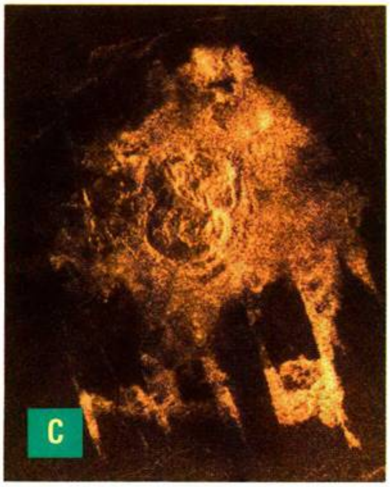




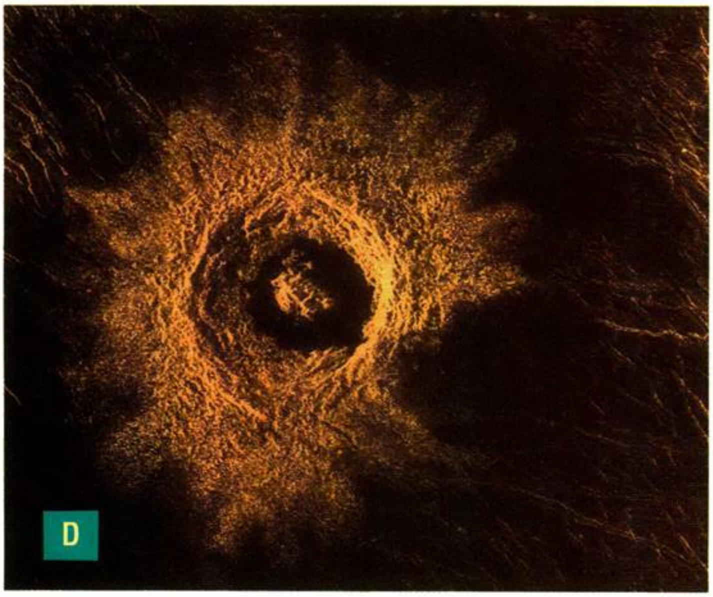
CRATERS ARE RARE on Venus, but highly interesting. **A:** Cleopatra Patera is an impact crater 100 kilometers in diameter much altered by volcanic lava. **B:** Craters such as Aglaonice (63 kilometers in diameter) show flooded floors, ejecta aprons, and a stream of lava from under the ejecta. **C:** Small craters (this one is 9 km across) typically show multiple floors caused by meteorites' breaking up before impact. **D:** Golubkina crater (34 km in diameter) shows a "butterfly" ejecta pattern because the meteorite struck obliquely. **E:** Double-ringed Mead crater is the largest yet found on Venus — 275 kilometers across.



to its features has turned out to be trickier than scientists originally hoped. In the solar system, craters make useful benchmarks in chronology. Planetary geologists studying images of a planet's surface know that cratering rates were high early in the solar system's history. Since then impact rates have declined in a pretty predictable way. When planetary geologists see a heavily cratered surface, they can assume they are looking at an old surface.



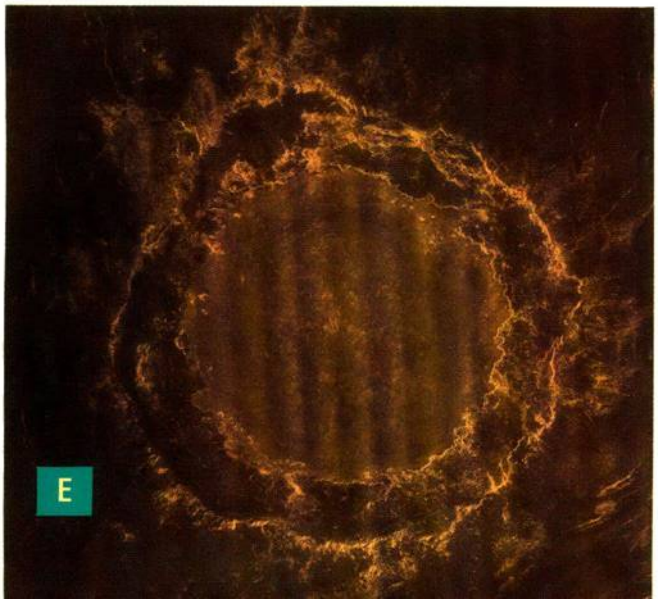
On Venus, however, two factors make craters less helpful in dating. First, craters are few in number. Extrapolating from the results of the first mapping cycle, project scientists expect that all of Venus has only about 1,000 craters larger than a few kilometers across. This is a larger number than has been found on Earth, but Mars, Mercury, and the Moon sport mega-multitudes that date back to the origins of the solar system. The small numbers on Venus make dating by crater counts a shaky proposition.



Second, while erosion does occur on Venus, the process is gentle. Thus there is no easy way to gauge a feature's age by how much it has eroded. "All Venusian craters are apprently fresh," remarks Saunders. This is not a problem for researchers dealing with other bodies. Wind and water erode the craters of Earth and Mars, while those of Mercury and the Moon suffer erosion of a different kind: from multitudes of micrometeorite impacts and the overlapping blankets of debris ejected from later impacts.

Few Big Basins

But despite their relative rarity on Venus, craters still have much to say about the planet's history. The largest Venusian impact yet known is a highly modified double-ring crater named Mead, which spans 275 kilometers in diameter (E, this page). While Mead preserves a two-ring structure, the crater's interior has been modified by debris and post-impact volcanism. Filled to the brim with a jumble of impact melt and lava, Mead lacks any visible central peaks, yet has hints of concentric fractures on its flooded floor. The inner ring is probably the original crater rim, and the land between the first and second rings appears to be a slumped terrace. The lava filling the center of the crater is lighter in tone — scientists interpret this as meaning that its surface texture is rougher, but the lava may also have a composition that reflects radar signals more strongly.



But Mead crater stands out for more than just size. It is also one of few large multi-ring basins on Venus; two others are Cleopatra (A, this page) and Klenova. Scientists attribute this lack of big impact scars to the relative freshness of Venus' surface. Presumably, when Venus was younger and large planetesimals were still common in the solar system, basin-gouging impacts were frequent. Once, Venus likely had dozens if not hundreds of basins in varying states of degradation, just as our Moon does. But the global resurfacing Venus has undergone — perhaps several times during its history — long ago erased all signs of these early asteroid strikes. Because big objects are less common today, and because the present Venusian surface records what has struck the planet over the last billion years at most, it's not too surprising that Mead has so few companions, and none as large. (Caution demands that a mental "yet" should be added to this, because a few others may still be found when Magellan has imaged the entire planet, including the high southern latitudes.)

Cleopatra offers a puzzle of its own, and perhaps an opportunity to probe the structure of part of Ishtar Terra, the large northern continent. Cleopatra is an impact crater surrounded by terrain that has been extensively modified by volcanism, probably induced by the impact. But Cleopatra lies on the slopes of Maxwell Montes, in a region where the crust is very thick. According to present thinking, if there was enough volcanic material available close to the surface so that it could spill out after an impact, then Maxwell itself would have softened and slumped to a much lower elevation. What's the answer? No one knows yet.

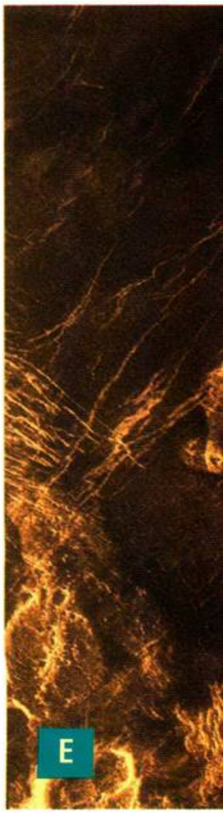
Small Craters and Smooth Places

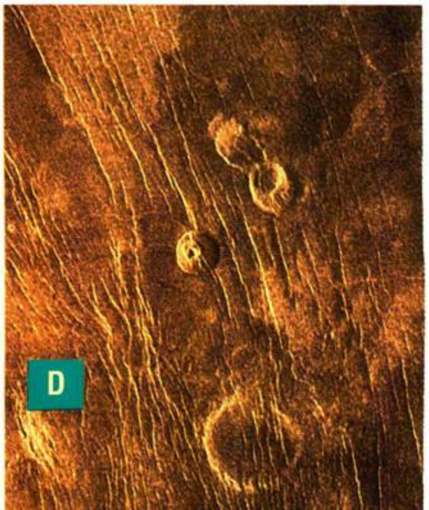
At the small end of the cratering scale, Magellan's surveys have not found any craters smaller than about 3 kilometers in diameter. This is due to the thick atmosphere which acts as a filter, destroying during passage any meteoroid that would make a smaller hole. Craters up to 15 kilometers in diameter typically have uneven floors with pockets of rubble or are found clustered in groups. Scientists think the impacting object was breaking up in the atmosphere when it struck the ground.

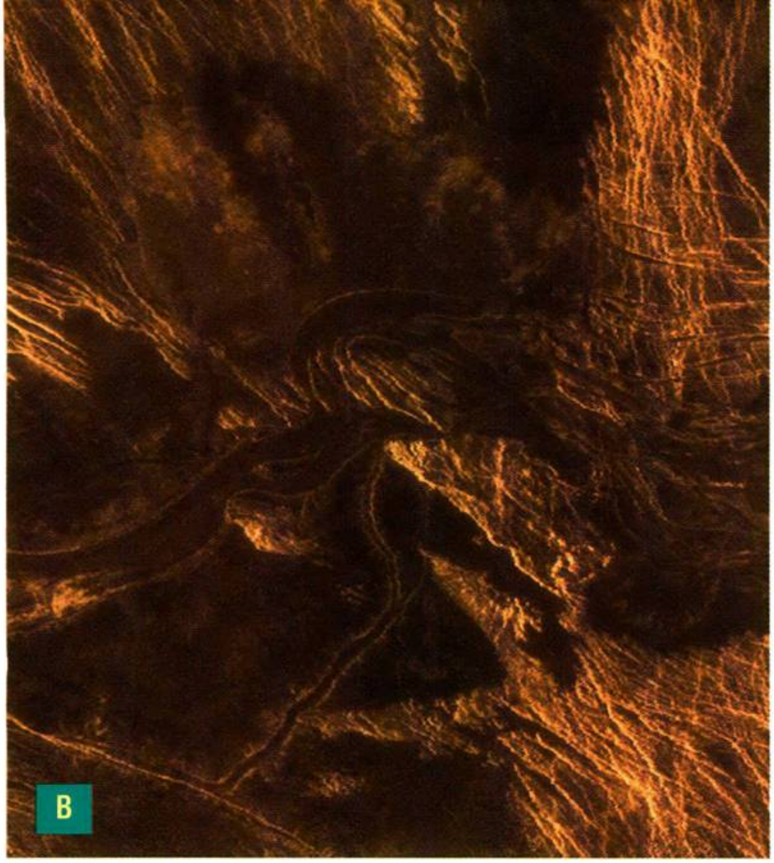
Incoming meteorites just *below* the cutoff size also leave a mark on the surface, though not a crater. Dark splotches are found in many areas of Venus, indicating that the surface texture is smooth on a scale of inches. Magellan scientists interpret these as places where ground has been brutally hammered by the shock wave from a meteoroid that didn't quite survive atmospheric passage. "To an incoming projectile the Venus atmosphere behaves more like a layer of water than any atmosphere in our everyday experience," says Roger Phillips of Southern Methodist University. When the meteoroid broke up completely, its shock wave continued onward to slam the surface with a blow hard enough to turn boulders into gravel — but not to leave a crater.

Another kind of dark marking is more enigmatic. Within 30° of the equator are craters that lie at the focus of large, parabola-shaped dark markings, 500 to 1,000 kilometers long. The dark parabolas all lie parallel to each other and all open toward due west.

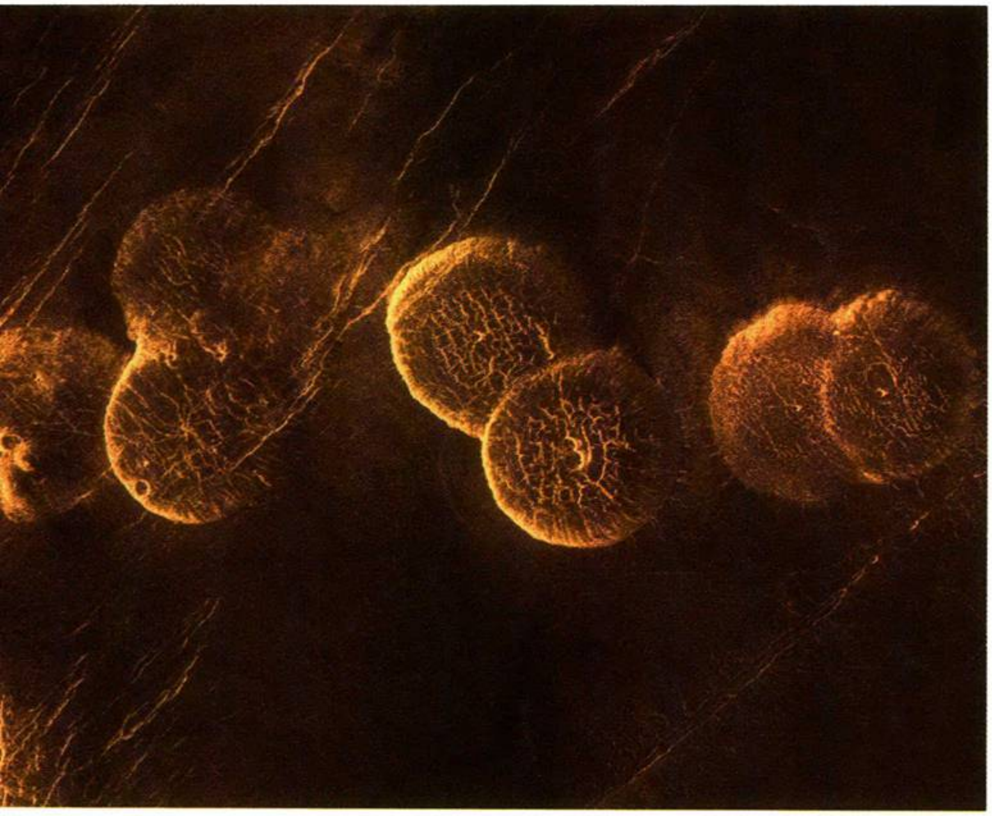
Are these a form of shock wave from oblique







VOLCANISM RUNS RAMPANT on Venus. **A:** In Lada Terra, multiple flows breach a folded range of mountains. **B:** A riverbed — in lava? Note the streamlined islands in this lava channel. **C:** "The Tick" is a strange dome that resembles some underwater seamounts on Earth. **D:** Domes and faults often show a complicated relationship. **E:** Pancake domes are built from stiff, pasty lava unlike the runny basalt that made the plains.



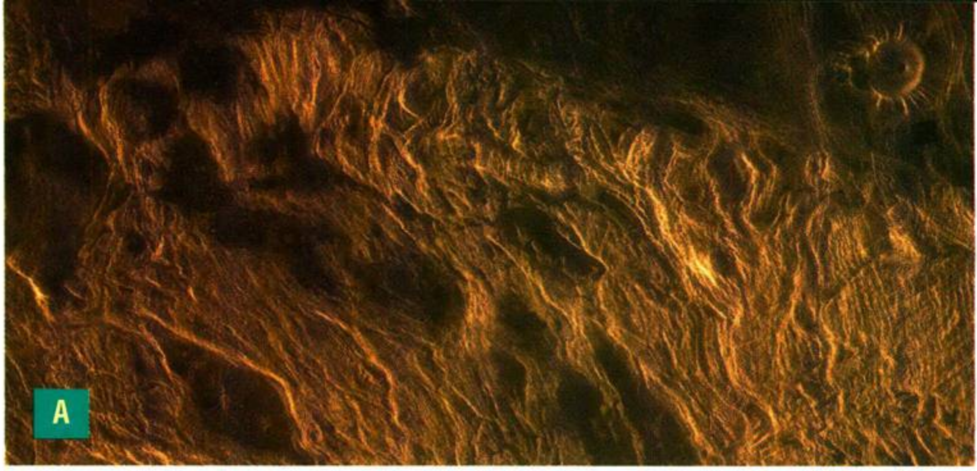
impacts? Scientists are not sure. For one thing, it would be stretching coincidence a lot to propose that all equatorial impacts land in the same oblique direction. Another possibility, though, is that the marks are wind-blown debris from the impact. Winds at the surface are only a few kilometers per hour, but at altitudes of 50 to 75 kilometers, equatorial winds blow due west at several hundred kilometers per hour. The length of the parabolas hints that a long-range process like wind was involved. The best explanation now is that the parabolic streaks are fine debris thrown high into the atmosphere by the impact and then carried westward by the high altitude winds.

The atmosphere affects Venusian craters at a more local level also. A great many craters display butterfly-shaped ejecta patterns. Calculations show that this results from impacts that strike the surface at an angle. But if that is the case, it's reasonable to ask why lunar and Mercurian craters don't show similar asymmetries. Once again, the answer lies in the thick atmosphere of Venus.

In a vacuum such as the Moon has, both dust and rocks fly unimpeded from an impact. Ejected debris tends to form a smoothly graded apron around the crater and, except for impacts at extremely shallow angles, the ejecta shoot in all directions about equally. Thus lunar craters look as if nearly all meteoroids struck in a straight-down direction. On Venus, however, the dense atmosphere complicates the situation. It interacts with the ejecta, transforming it into a dense, turbulent flow. The result is that lobes of ejecta do not go far and are stubby in appearance. Second, many ejecta aprons are butterfly-shaped because when the impact is oblique, the wake of the incoming meteoroid prevents the ejecta from scattering back in the direction from which the meteoroid came. The result is a splash pattern with one "stunted" section mapping the direction from which the meteorite arrived.

Volcanism: Lava, Lava Everywhere...

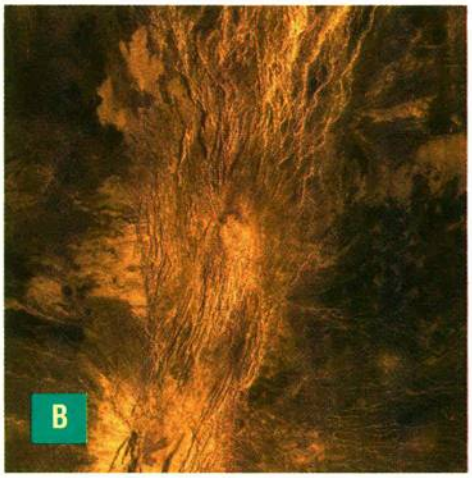
Impacts can do more than blast a hole in the ground; they can also open a pathway for lava. All craters larger than about 20 kilometers across have interiors at least partially



flooded with lava. In addition, many craters, including the three large ones in the "crater farm" region near Alpha Regio, have lava flows that ooze out from beneath their ejecta blankets like blood beneath a bandage.

This points up a remarkable fact. Venus is volcanic to a degree unmatched on Earth. Apparently all of its rocks are volcanic in origin, and for as much as 90 percent of its surface, volcanism was the last geological process to occur. The high level of volcanic activity has kept the surface of Venus fresh, at least in solar system terms. The entire planet appears to have been resurfaced in the last several hundred million years, although scientists are not certain if this happened in a single global cataclysm or if the repaving took place locally in small eruptions spread over a longer time.

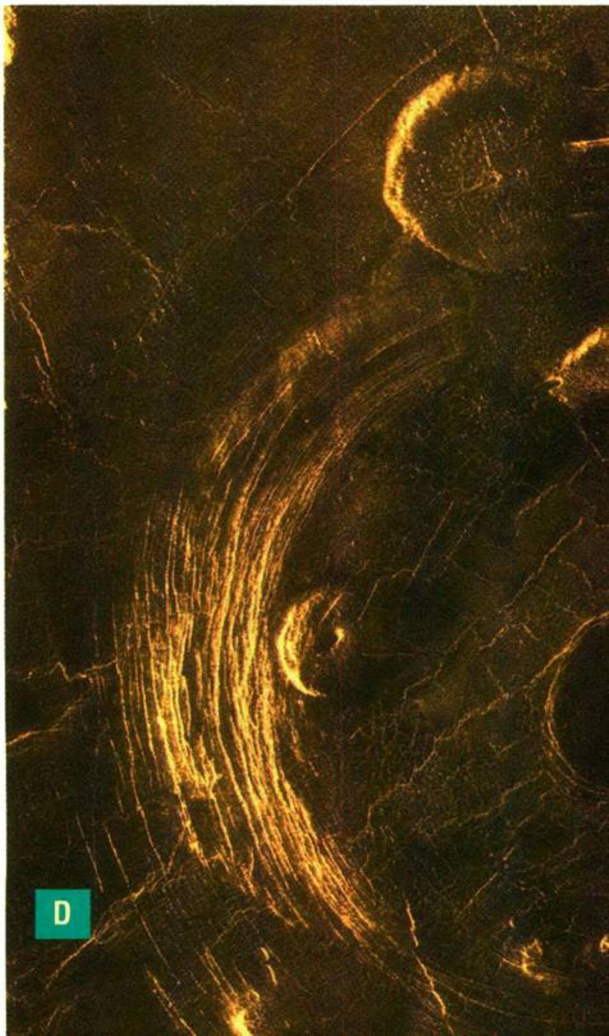
The plains covering most of Venus show four main kinds of structure: smooth, reticulated, gridded, and lobate. The smooth plains come from volcanic flooding, and the reticulate are like smooth plains but with sets of irregular grooves. They appear to cover earlier terrain and have been deformed. The gridded plains have bright, narrowly and regularly spaced cracks — once again the result of deformation, perhaps as a thick lava flow cooled — and the lobate plains represent the merging of smaller volcanic flows and groups of flows.

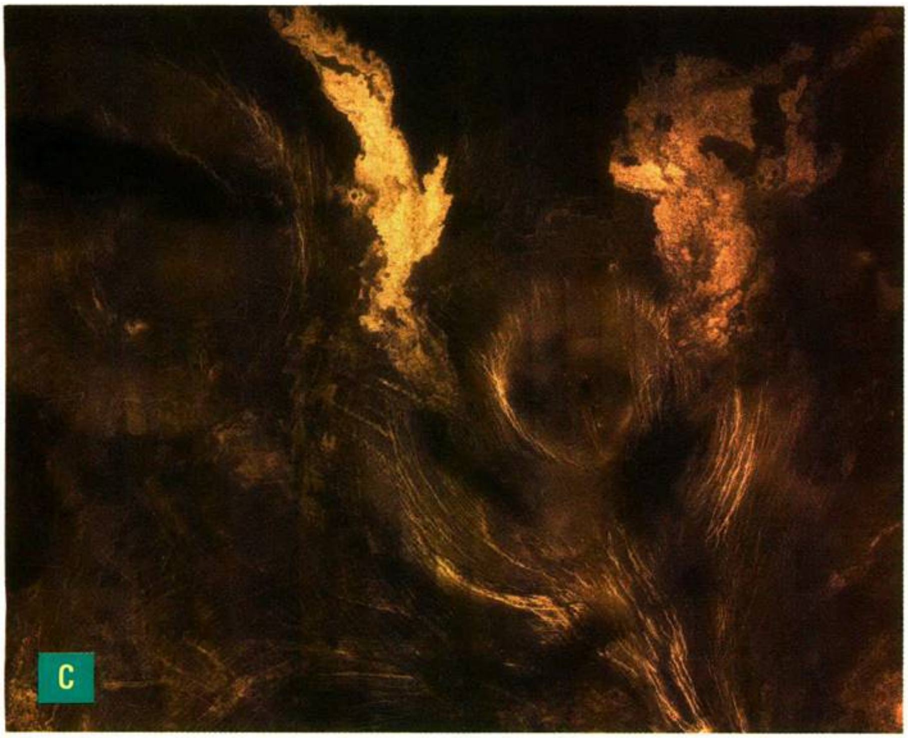


Magellan's radar images show that in places the lava flows were extremely fluid. Molten rock appears to have flowed about as easily as cooking oil, heavy cream, or paint, and often it ran for many hundreds of kilometers, even down slopes as gentle as 0.1° (roughly, a drop of 1 inch in 50 feet). While Earth has flows as long as those on Venus, they are rare. It is not clear yet why the lava should be so runny, but it is not due to the high surface temperature (750 kelvins, or 900° Fahrenheit). The atmosphere actually cools the lava's surface quickly. Why? Although the atmosphere is hot, it is considerably cooler than the lava, plus it is very dense (90 times Earth's pressure). It therefore acts as an efficient coolant for molten rock, chilling the lava's surface much as terrestrial ocean water cools an undersea eruption.

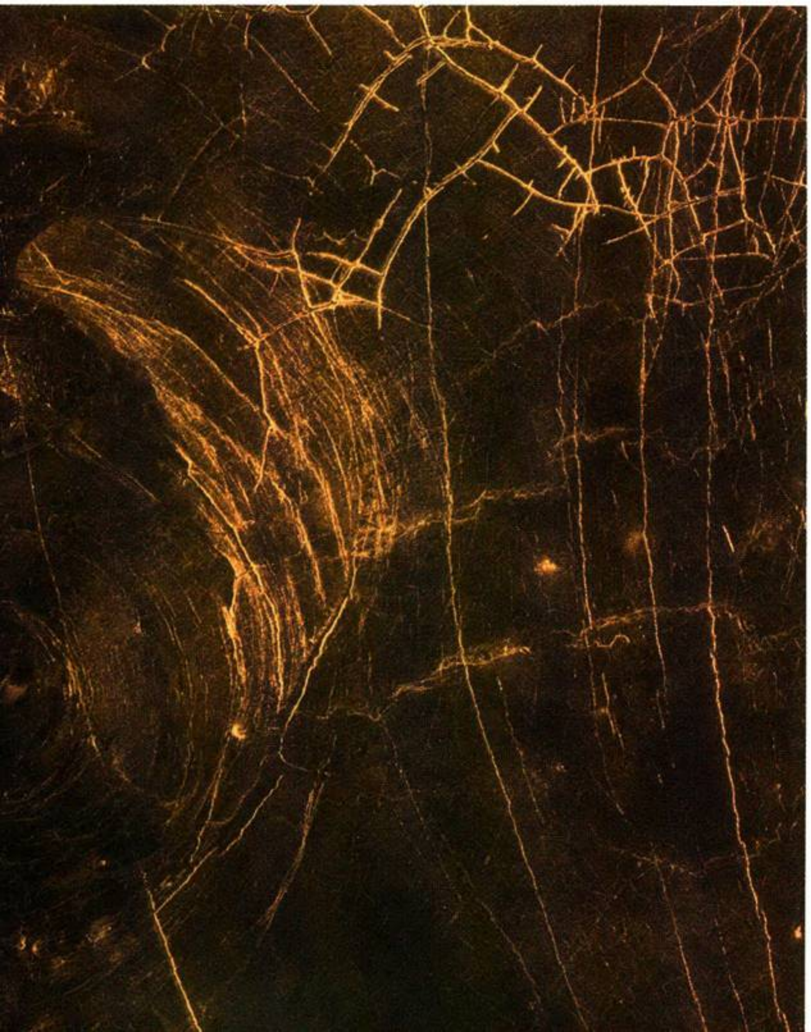
But under the hardened insulating crust, Venusian lava continues to flow freely and in quantities that are matched on Earth only in the vast areas of flood basalts found along the Columbia River in Washington state and in India. Whenever a flow persists for a time in a given place, it creates a channel for itself with levees. Fresh lava spilling across old lava can burn a channel to flow in, much as a river carves a bed in loose sediments. "Thermal erosion has created sinuous channels up to 2,000 kilometers long," marvels James Head of Brown University. Channels cut by hot lava can bear an astonishing resemblance to those carved by water. For instance, Magellan scientists noted that in Lada Terra, flowing lava has created features that look like the streamlined islands and channel bars seen in the water-carved outflow regions of Mars (A, page 36).

Radar images also show that many flows occurred in stages or renewed their activity intermittently. In Mylitta Fluctus, for example, radar-bright flows mingle with dark ones in tangled sequences that will require patience to unravel into a proper relative chronology. (The Mylitta flows record at least five and perhaps ten episodes of flooding.) The flows also raise more general questions. Why do neither the smooth-





TECTONIC MOVEMENTS create landforms, as on Earth. **A:** Northern Alpha Regio in detail. **B:** Devana Chasma is a rift zone with multiple faulting and deep fractures. **C:** Circular fractures in this corona in Sedna Planitia have emitted at least two bright, radar-rough lava flows. **D:** Aine Corona shows several pancake domes that appear influenced by the fractures.



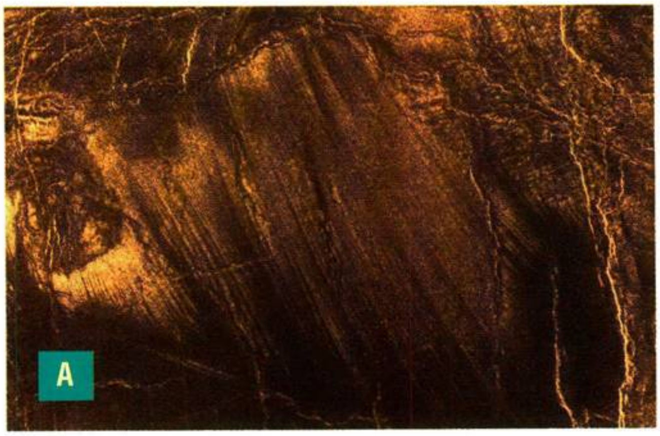
textured dark flows nor the bright flows, which have surface textures that are rough on a scale of a couple of feet, match the radar signatures of their closest terrestrial analogs? Why do the same vents produce both bright and dark flows? Does the character of the lava change as the eruption continues? According to terrestrial experience, dark (smooth) flows should be more fluid than the rough, clinkery kind, and terrestrial lava usually *does* change character during an eruption. But how our Earth knowledge relates to that of Venus is still unclear.

If Venus has lots of fluid lava, it also has some that was more pasty in consistency. Magellan found domes whose steep sides indicate they were built out of stiff, high-viscosity lava. Ranging from 30 to 60 kilometers across, these pancake domes rise about 100 to 600 meters. Their upper surfaces are often faulted and cracked like breadcrust, showing the dome grew in stages as lava was injected under a cooled, hard shell that broke and reformed. Other domes with lower slopes display smooth surfaces and pit craters at their summits. These are probably calderas that opened up by collapse when the lava supply filling the domes retreated.

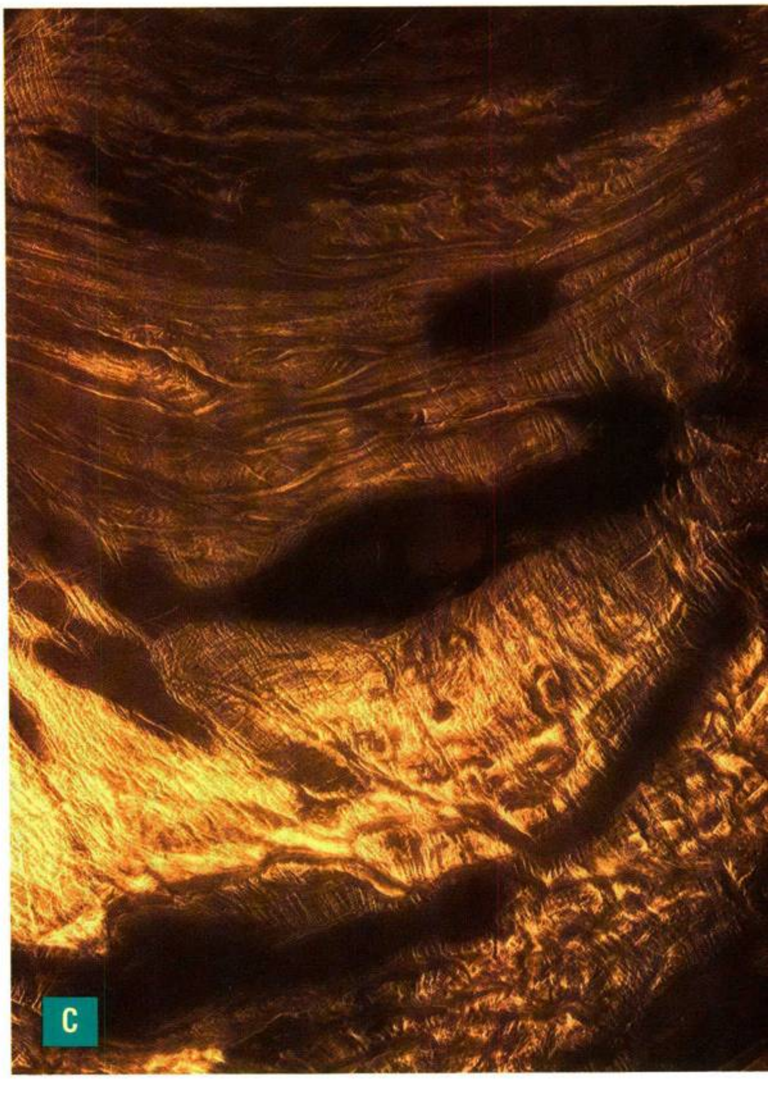
Domes often occur in fields, which some scientists think map the extent of the lava reservoirs under them. The fields typically show a range of age — some domes sit astride faults and cover them, while other domes are broken by faults. Dome fields are usually absent in the vicinity of large volcanic structures, as if the big structure hogged most of the lava and deprived the surrounding region of it. One dome in Alpha Regio appears unique. About 35 kilometers across, it has been dubbed "the Tick" or "Tick Mons" for its resemblance to the insect (C, page 36). It has a central caldera in a concave, sloping summit from which lava has flowed westward. Around the edge of the Tick are spokelike ridges whose origin is unknown. "We think the best Earth analog for this is a type of seamount on the floor of our oceans," remarks Head.

The dense atmosphere also lends the slow Venusian surface winds surprising force. They blow only a few miles per hour, but their high density means they can move material that would lie undisturbed in a terrestrial breeze of that speed. "In their effects, the winds are more like 15-mile-an-hour winds on Earth," says

Saunders. These winds have produced a range of effects. For example, near a lava stream flowing north from Aglaonice crater, radar detected a soft, "speckly" texture. Based on terrestrial analogs, this is likely a field of dunes. In another image, taken in a field of volcanoes, images show radar-bright patches on one side. Project scientists interpret the patches as being places where dark material, possibly erupted by the volcanoes themselves, has been scoured away from a rougher underlying surface by wind eddies.



These volcanoes may also indicate areas with unusual degrees of eruptive activity. On Earth, structures like these result from explosive eruptions that occur when dissolved gases burst out of solution as the lava nears the surface. On Venus, the high atmospheric pressure tends to keep gases dissolved in the lava, unless they are unusually volatile. Therefore some Venusian volcanoes may mark places where lava comes out extra-rich in gases — a useful point to note as scientists weave together a geological picture of the planet.



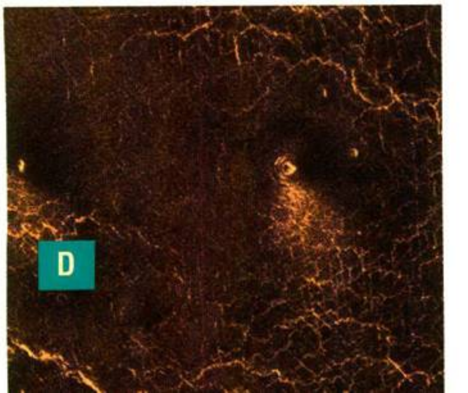
Tectonics: Moving Venus to Make a Mountain

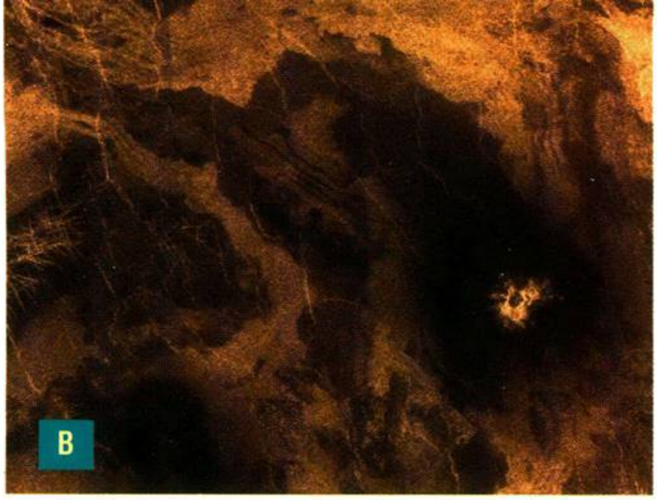
"My biggest surprise," remarks Saunders, "is Venus' lack of any ancient cratered terrain similar to the Moon's southern highlands." Saunders continues, "Over 80 percent of the planet is covered with volcanic plains material" of one kind or another. But the remainder shows clear signs of tectonic activity — the folded and faulted ridge belts that resemble one kind of mountain-building on Earth. Tectonic activity doesn't account for much of the Venusian surface, but it may offer a look at deeper processes than volcanism.

The two large highland regions — Ishtar Terra in the north and Aphrodite Terra at the equator — contain a diversity of features. In Ishtar, the most outstanding and puzzling are the tesserae, regions of tangled, faulted topography that stand 1 to 2 kilometers higher than the volcanic plains. A typical tessera block is rough-textured, both at a feet-and-inches scale and a scale of kilometers. Tesserae appear to be regions where the Venusian crust has been pushed together. Ishtar consists of a large flat block called Lakshmi Planum, which is surrounded by regions of tessera that tectonic movements have thickened into mountains — in the case of Maxwell Montes, the summit rises 11 kilometers. Some scientists think that Ishtar is a continent built by a massive pileup of crust; others are not sure.

Aphrodite Terra appears to have a different structure than Ishtar and at one time was thought to be a place where plate tectonics is now occurring or has in the past. The Magellan results, however, show that if Venus has a global plate-tectonics network, it is unlike Earth's. Under investigation now are alternative possibilities for Aphrodite: that it stands over a rising hot spot, and that it could be a site where the crust is descending into the mantle. Unfortunately, the Magellan results can be interpreted both ways. Grins Saunders, "We're all agreed that there's convection here, but its sign [up or down] is unclear!"

Other tectonic features occur on smaller scales. Coronae, for example, are circular or oval structures 200 to 1,000 kilometers in diameter

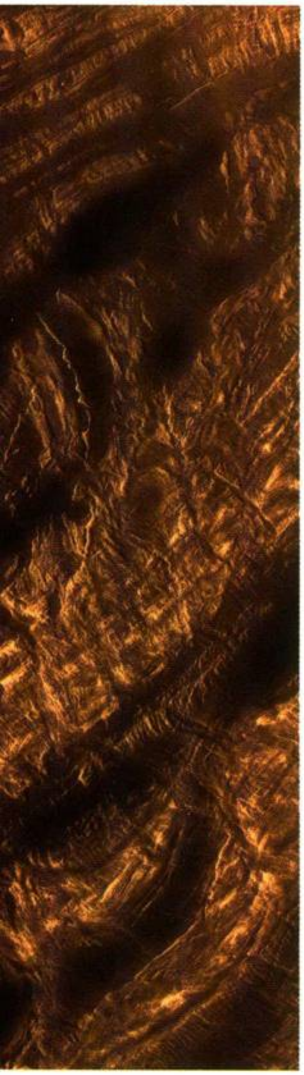


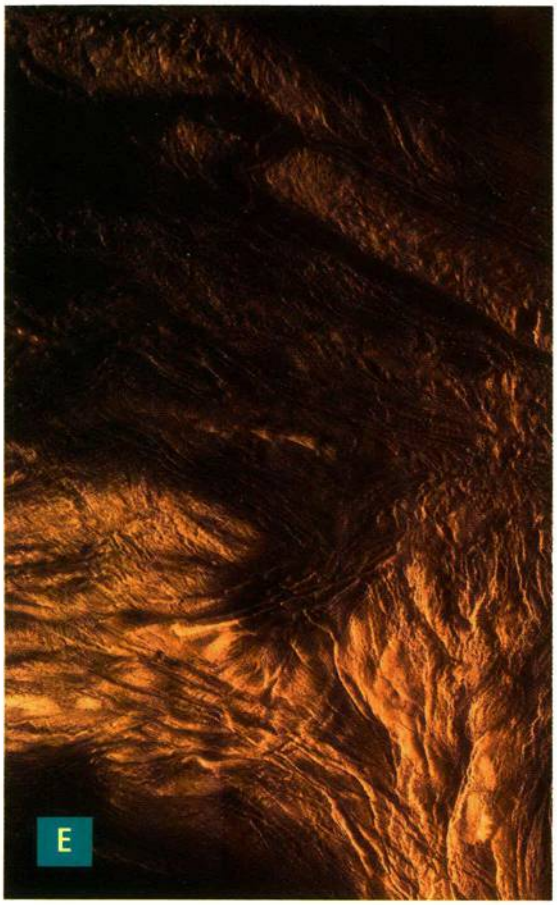


with raised centers and narrow rings of concentric ridges. Because of their symmetry and the abundance of volcanic landforms associated with them, scientists think coronae are surface features produced above hot spots, columns of hot rock rising from the mantle. Larger than coronae, but also related to hot spots are the big elevated regions such as Beta Regio. Over an area a thousand kilometers across, Beta displays a dazzlingly complex array of features, including rift valleys and shield volcanoes. The images from Magellan are rich in detail, but so far the puzzles are more numerous than the answers, and scientists are only at the beginning of understanding how this part of Venus "works."

Interior: Murky Views but Better to Come

The debate over the plate tectonics question mirrors a like uncertainty about the structure of Venus. At this point, it's too soon to say very much about it. Venus has a high degree of volcanism and local outbreaks in places like Beta Regio. These are similar to places on Earth like Hawaii or Iceland. The tangled, knotty ridge-belt mountains also mimic some mountain ranges on Earth. But the lack of a global network of rifts like Earth's shows that Venus has fundamental differences from our planet. One possibility being studied at present is that Earth's abundant water lubricates our plate tectonic "machine," allowing for easy plate movements. Venus is extraordinarily dry, however, and because it lacks water, its geological recycling machine may have seized up tight.





GEOLOGICAL RELATIONSHIPS can be complex. **A:** Streaks in Ovda Regio are probably debris from Mead crater rearranged by wind. **B:** A small crater (right) landed on a field of light and dark flows; its dark halo is probably a shock effect of the impact. **C:** In central Ovda Regio, lava flows invaded the fold-belt mountains. **D:** Wind has scoured the ground in the lee of these volcanoes, exposing the light-colored bedrock. **E:** More fold-belts and lava, on the northeastern edge of Lakshmi Planum.

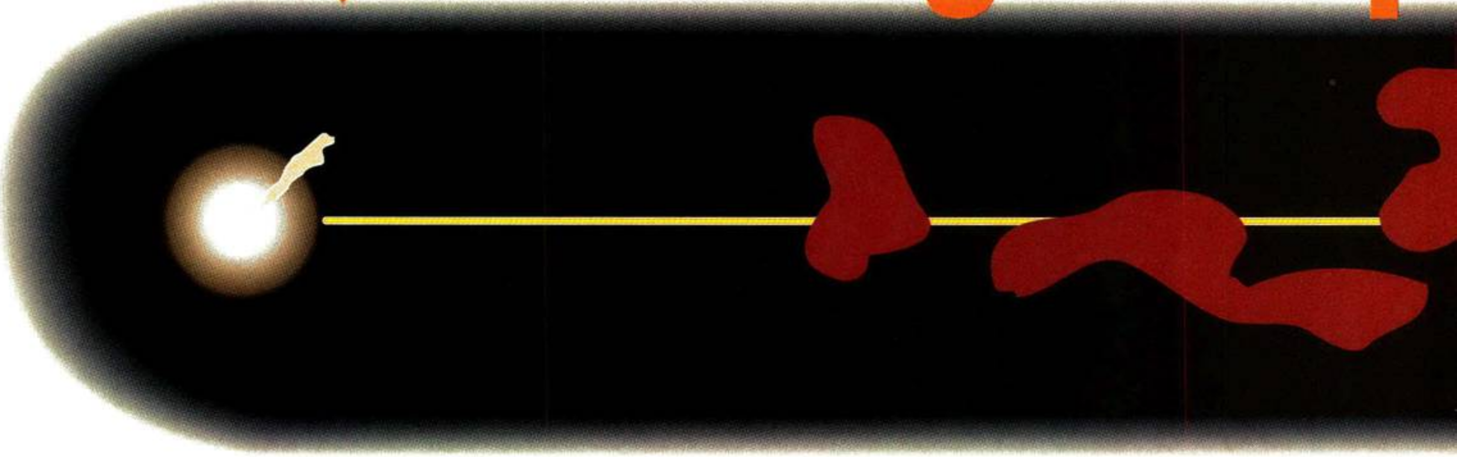
Good theories depend on good data, and project scientists hope to learn much more about the planet's interior when Magellan starts detailed investigation of Venus' gravity field. Knowing in detail where Venus is denser or lighter should provide a good look into the depths of the planet, highlighting the crustal structure under the plains and tesserae.

Now that Magellan has completed its first mapping cycle, flight controllers are commanding it to fill in the gaps in the first cycle's coverage and to begin surveying the still-unexplored southern latitudes omitted from the first cycle. "We have plans for the spacecraft through cycle 7," says Saunders. One of the plans even includes lowering Magellan's orbit (to gain 3 times better resolution) by briefly dipping into the uppermost atmosphere! After cycle 7, which will be complete in June 1995, Magellan will be nearing the end of its operational lifetime. What will it have accomplished by then? Already Magellan has mapped the landforms and features of Venus more completely than anyone has mapped those of Earth, where the ocean basins still remain largely *terra incognita*.

In the meantime, many exciting discoveries lie ahead — including, perhaps, wholly new kinds of features — as Magellan begins imaging the south polar region. □

HUBBLE
REPORT

A Quasar Lights Up



Quasars are among the most exotic beasts in the entire astrophysical zoo. These ultraluminous objects pump out as much energy as a hundred or more galaxies from a volume sometimes no larger than that of our solar system. Because they are so luminous, quasars can be seen across the depths of space from near the edge of the observable universe.

Quasars are fascinating not only in their own right but also as unique probes of otherwise invisible matter in space. As the light from a quasar makes the long journey to Earth, it passes through a lot of intervening material. By analyzing the quasar's light, astronomers can learn a great deal about this material that would be impossible to find out any other way.

Now astronomers have observed the bright, nearby quasar 3C 273, located about 2 billion light-years away, with the Hubble Space Telescope (HST) and found a lot more *clouds of intergalactic hydrogen* in our part of the universe than anyone expected. Based on previous observations of much more distant quasars, astronomers predicted only one or two clouds of intergalactic hydrogen would be found in the spectrum of 3C 273. Instead, one observation turned up 5 to 7 clouds and a second, independent observation found 9 to 16 clouds.

The surprising implication is that there has been no appreciable change in the number of hydrogen clouds in the universe over the past 10 billion years or so. How new clouds can form at the present time or how old ones could survive for several billion years is anyone's guess, so the new findings will keep theoreticians busy for a while.

Telltale Lines in the Spectra

The historic discovery of nearby hydrogen clouds rests on four key elements that might appear unrelated at first glance: the characteristics of quasars, the expansion of the universe, the nature of light, and the unique capabilities of HST. The quasar acts like a searchlight, "lighting up" the material that lies between it and Earth. And it does this by emitting copious amounts of radiation over a broad range of wavelengths.

Because the universe is expanding and thus all objects outside our Local Group of galaxies are moving away from us, the radiation emitted by the quasar is shifted to longer wavelengths, or redshifted. (Since red is the longest wavelength of visible radiation, any shift to longer wavelengths is called a redshift.) In an expanding universe, the farther away an object lies, the faster it moves away from us. And the faster it moves away, the more its light shifts to the red. For the relatively nearby quasar 3C 273, the shift is a modest 16 percent, but for quasars near the edge of the universe, their light can be shifted by 400 percent or more.

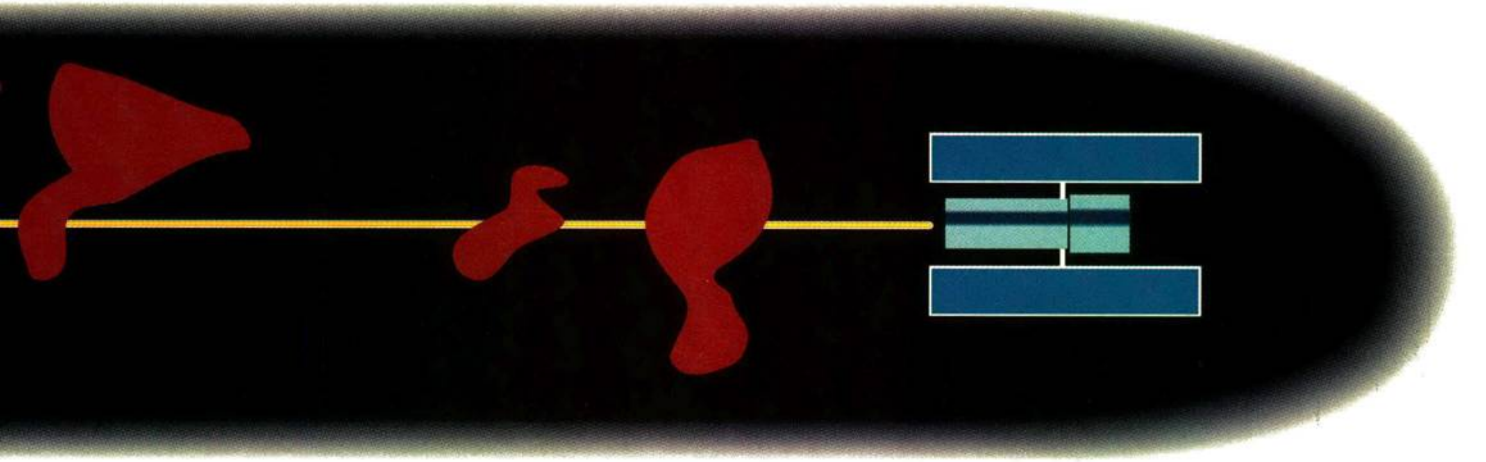
Now imagine that a cloud of intergalactic hydrogen lies between the quasar and Earth. As the quasar's light passes through the cloud, the cloud's hydrogen absorbs light at certain discrete wavelengths. The strongest of these absorption lines is the Lyman-alpha (Lyman-α) line, named for the American physicist Theodore Lyman who first measured this part of the hydrogen spectrum in the early 1900s.

In the laboratory, the Lyman-α line has a wavelength of 1216 angstroms. But the intergalactic hydro-

Space Telescope observations of a nearby quasar have uncovered far more clouds of intergalactic hydrogen than expected.

by Richard Talcott

the Universe



THE LYMAN-α FOREST FORMS when light from a quasar passes through intergalactic clouds of hydrogen. Each cloud absorbs light from the quasar, producing an absorption line with the redshift of the moving cloud. Illustration by Tom Hunt.

gen cloud is also part of the expanding universe, so it too is moving away from Earth. Thus, the Lyman-α line is shifted from 1216 angstroms to a longer wavelength determined by the cloud's speed of recession and, consequently, distance.

Now suppose that several hydrogen clouds exist along your line of sight to the quasar. Each cloud will impart its spectral signature onto the quasar's spectrum, which may end up with a thicket of Lyman-α absorption lines. Astronomers have dubbed this region of a quasar's spectrum the "Lyman-α forest." By examining the spectrum in detail, an astronomer can deduce how many clouds of hydrogen lie along our line of sight to the quasar and how far away each of those clouds is. (The analysis is complicated by absorption lines from gas in the interstellar medium of our own Galaxy — an interesting study in its own right. Fortunately for the people interested in the Lyman-α forest, these lines are known well enough that they can normally be subtracted from the spectrum.)

The final key is HST. Earth's atmosphere blocks most ultraviolet radiation that tries to pass through. Although that's fine for people and other living things, it means that ultraviolet astronomy can be done only from above the atmosphere. And because the Lyman-α forest for nearby quasars lies entirely in the ultraviolet, no definitive studies could be done until now. (The International Ultraviolet Explorer satellite did not have enough sensitivity to see these spectral lines.)

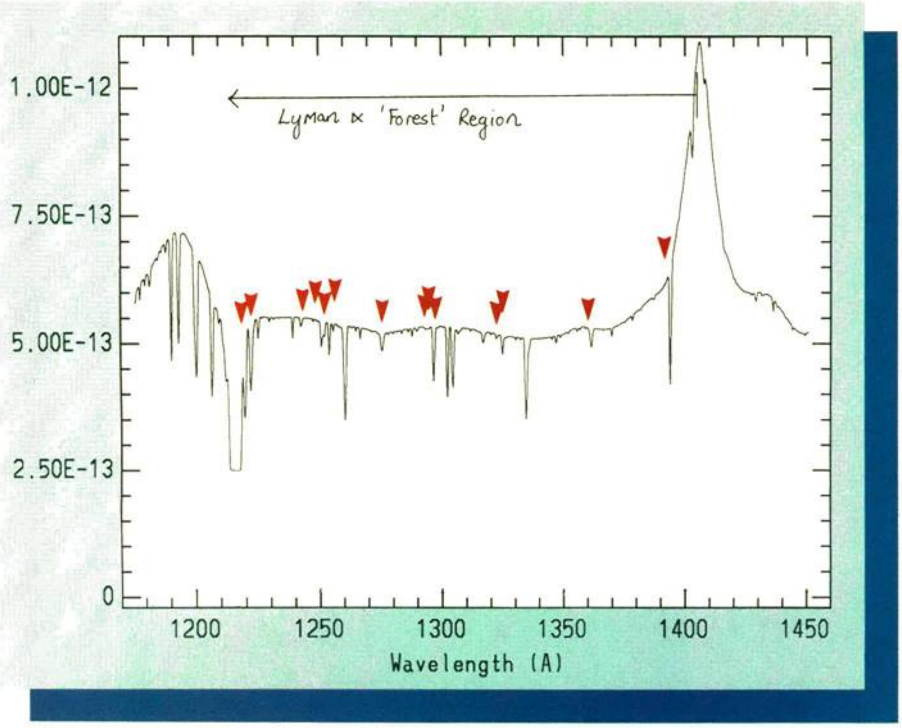
Studying absorption lines in quasar spectra is such a powerful technique that it was made one of the three key projects for the 15-year Hubble mission. With Hubble's optical problem, the two other key projects — measuring the distance scale of the universe and the medium-deep survey, which is designed to image blank areas of the sky to search for the unexpected — have been put on hold until after the 1993 shuttle servicing mission. Thus, studying the quasar spectra is one of the hottest projects going.

The Nearby Clouds

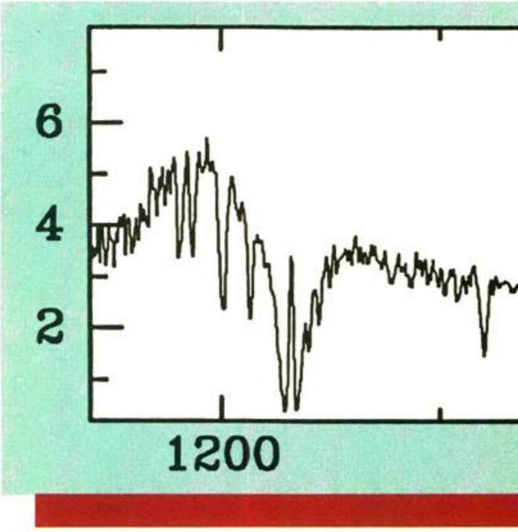
Two teams of researchers targeted 3C 273 early this year. The first group, led by John Bahcall of the Institute for Advanced Study in Princeton, New Jersey, observed the quasar on January 14-16, while the second, led by Simon Morris and Ray Weymann of the Observatories of the Carnegie Institution of Washington, pointed HST at the quasar on February 23.

According to Bahcall, "I didn't know what to expect from the observation. We had no guarantee that we would see anything." Many studies of the Lyman-α forest in high-redshift quasars have been done before, but extrapolating results from them to low-redshift quasars is tricky. (High-redshift quasars can be studied from the ground because much of the Lyman-α forest is redshifted from ultraviolet to visible light, which can penetrate Earth's atmosphere.)

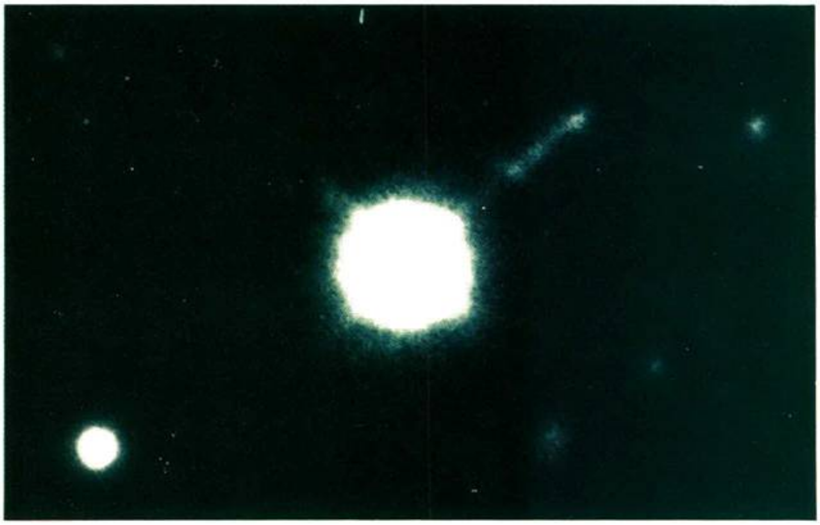
Earlier studies of high-redshift quasars showed that the number of



LOADS OF LYMAN-α LINES appear in the Lyman-α forest of 3C 273. The "forest" extends from 1216 angstroms, where we see Lyman-α absorption from our Galaxy, to 1406 angstroms, where Lyman-α emission from 3C 273 is redshifted to. The other absorption lines in the spectrum come from heavy elements in our Galaxy. GHRS spectrum courtesy Simon Morris.



THE FIRST ULTRAVIOLET SPECTRUM OF 3C 273 came from the Faint Object Spectrograph, which revealed at least five Lyman-α lines between 1216 angstroms and 1406 angstroms. Spectrum courtesy John Bahcall.



SEARCHLIGHT IN SPACE, the quasar 3C 273 probes the matter between galaxies and reveals otherwise invisible clouds of hydrogen. NOAO photo.

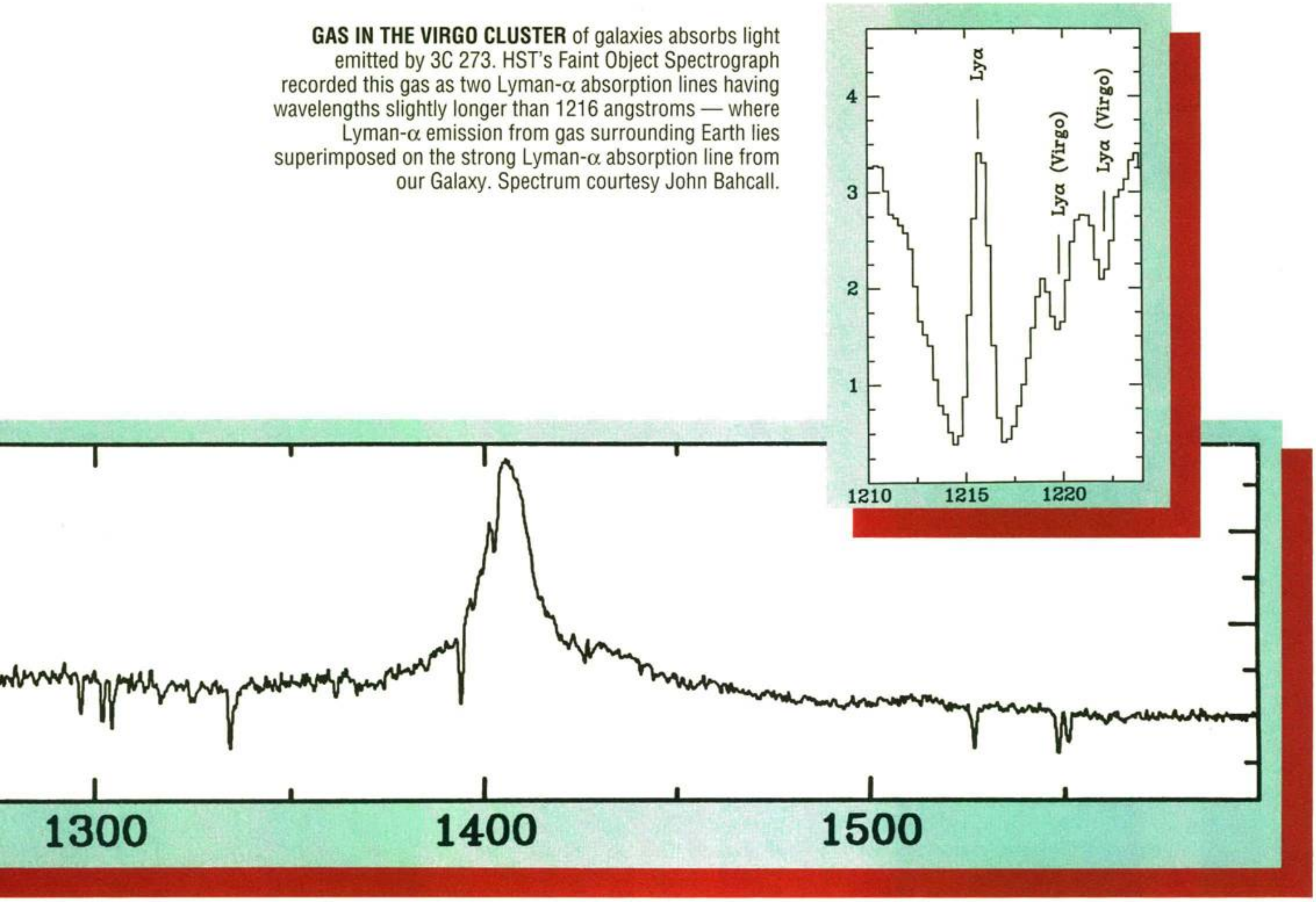
Lyman-α lines increases dramatically as you go to higher redshifts. But at redshifts of 2 or slightly lower, the limit beyond which the lines can't be observed from the ground, the number of lines falls dramatically. The obvious interpretation is that the clouds creating the Lyman-α lines were more numerous early in the history of the universe than they are now. In fact, by continuing the trend seen at higher redshifts to lower redshifts, the number of expected Lyman-α clouds in nearby intergalactic space falls to nearly zero.

But the numbers seen by HST in the spectrum of nearby 3C 273 were far from negligible. Bahcall's team, observing with HST's Faint Object Spectrograph (FOS), identified five Lyman-α lines in the spectrum and saw two other lines that might be due to Lyman-α. Morris and Weymann's team, observing with the Goddard High Resolution Spectrograph (GHRS), found nine convincing lines and seven others that were good candidates. (The GHRS has greater spectral resolution than the FOS and can thus distinguish more lines.)

The higher-than-expected numbers seem to show that the intergalactic hydrogen clouds have evolved very little over the past several billion years. The obvious conclusion, according to Morris, is that "either there are physical processes at work at the present epoch which can generate new clouds, or else clouds that formed long ago are somehow stabilized by an extremely efficient mechanism."

Another very significant result to come from the study is the discovery of two Lyman-α lines originating

GAS IN THE VIRGO CLUSTER of galaxies absorbs light emitted by 3C 273. HST's Faint Object Spectrograph recorded this gas as two Lyman-α absorption lines having wavelengths slightly longer than 1216 angstroms — where Lyman-α emission from gas surrounding Earth lies superimposed on the strong Lyman-α absorption line from our Galaxy. Spectrum courtesy John Bahcall.



from hydrogen in the Virgo Cluster of galaxies. The redshifts of these two lines (seen in both the FOS and GHRS data) correspond to distances that place them in the Virgo cluster. The spectral lines presumably come from gas within the cluster or from the halos of Virgo Cluster galaxies. This discovery proved particularly satisfying to Bahcall, who along with Ed Salpeter in 1969, predicted that galaxy clusters should give rise to absorption lines in quasar spectra. The current observations confirm that prediction and offer hope for learning more about the cluster's environment.

Clouds of Mystery

What are these Lyman-α clouds? Although no one yet knows for sure, two plausible theories exist. They could be large halos of hydrogen that surround galaxies, or they could be isolated hydrogen clouds that never got incorporated into galaxies. It's also possible that both types of cloud exist and cause the absorption lines.

But whatever they are, the Lyman-α clouds may one day provide important information concerning a variety of astronomical questions. How is matter distributed in space and how does it evolve with time? If the Lyman-α clouds act as tracers for other matter, then observations of them at as many redshifts as possible could play a key role in answering that question. The observations of 3C 273 have already added fuel to that debate by showing there has been little change in the number of Lyman-α clouds over the past several billion years.

Another important topic addressed by observations of Lyman-α clouds is the physical state of the intergalactic medium. Astronomers have few techniques for studying the intergalactic medium, but that's right where the Lyman-α clouds reside. Studying the Lyman-α clouds in a large number of quasar spectra could give astronomers a good handle on what's going on between the galaxies.

That's where HST comes in. According to Bahcall, who is spokesman for the quasar absorption line key project, the first observations for the project were scheduled for July 1. (Surprisingly, neither of the current studies was done as part of the key project. Bahcall's team made their observation under the science verification program designed to assess the telescope's capabilities in the wake of the primary mirror's spherical aberration, while the group led by Morris and Weymann worked on their own guaranteed time observer program.)

The project will target 30 quasars out to a distance of about 10 billion light-years (a redshift of 2). However, most of the quasars in the study lie within a redshift of 1.5; a few with redshifts between 1.5 and 2 were added so there would be some overlap with ground-based observations. Meanwhile, observations of more distant quasars will continue from the ground.

But right now, John Bahcall feels relieved. "We saw much more [in the spectrum of 3C 273] than we expected, so we now know we're going to see *something* in our studies." What they see will take years to digest, and it's unclear where it will eventually lead. For now, we know that our local neighborhood of the universe isn't as empty as we had thought, and the universe as a whole is filled with many surprises just waiting to be discovered. □

HUBBLE
REPORT

New Views from Hubble

Astronomers using HST are targeting some of the universe's most interesting objects.

The Hubble Space Telescope is now well into its second year of operation. The long, involved process of assessing the telescope's capabilities in light of the flawed primary mirror is slowly giving way to detailed science observations. And as images and spectra are beamed back to Earth at an ever-increasing rate, astronomers are getting their first detailed views of many fascinating subjects.

The newest planetary portrait to come from the orbiting observatory is that of Jupiter — the largest planet in the solar system and the one with the most dynamic atmosphere. HST's Planetary Camera captured the giant planet on March 11 (right), revealing a level of detail not seen since the Voyager spacecraft flybys in 1979.

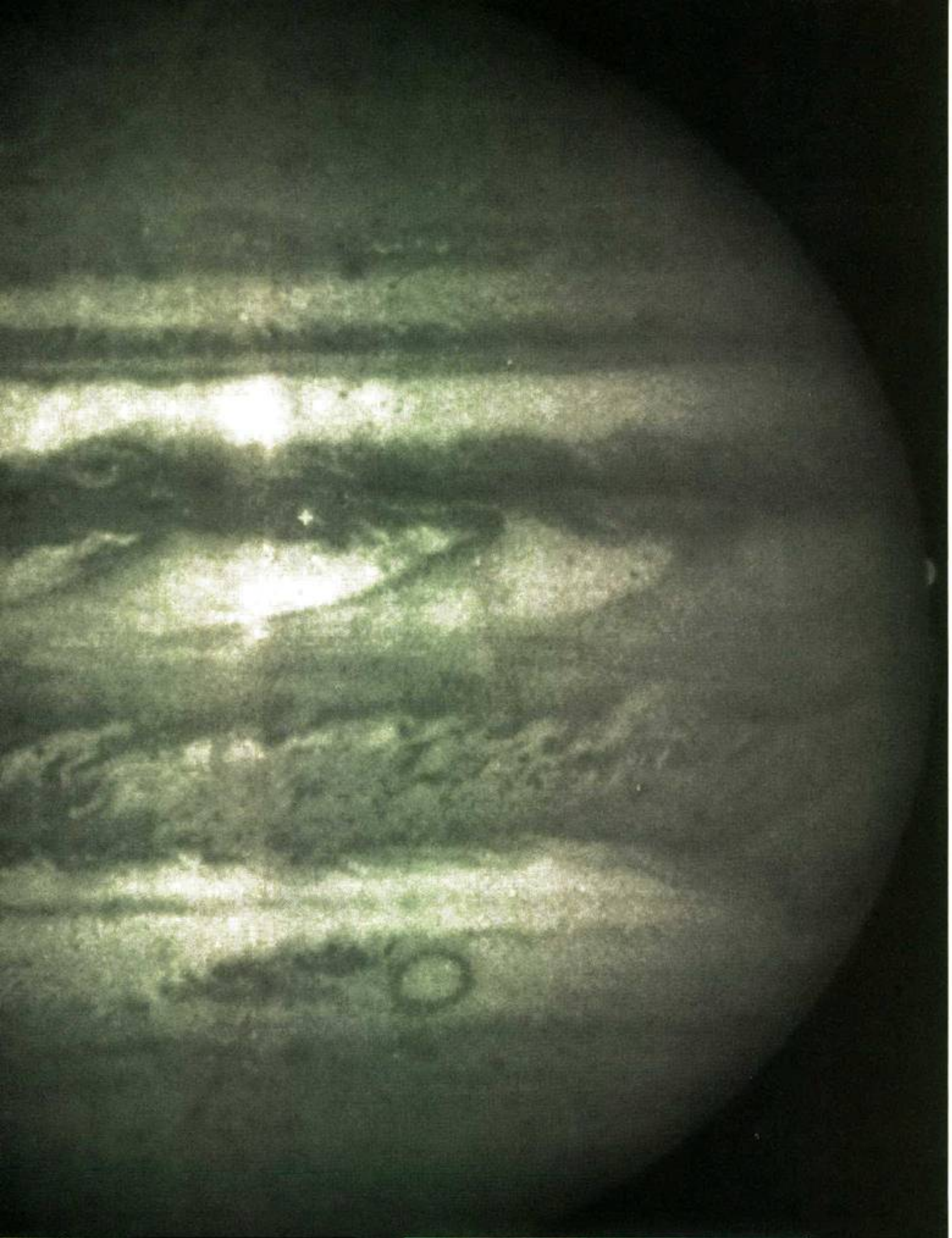
The black-and-white image, which was taken through a green filter, is as sharp as images taken by Voyager five days before closest encounter. Easily seen in the complex, banded atmosphere are the Great Red Spot near the southeastern limb (lower right), a white oval to the lower left of that, and dark, "j"-shaped clouds along the equator caused by intense jet streams in the Jovian atmosphere.

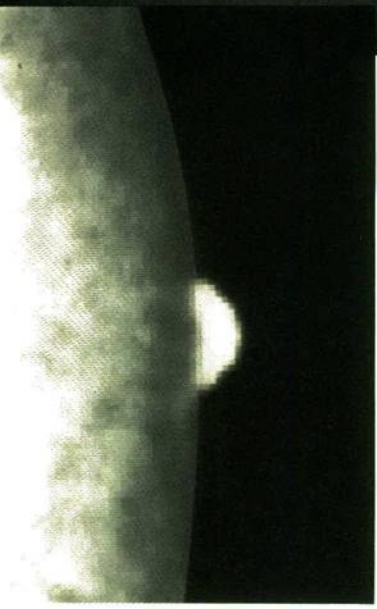
Comparing this image to those taken by Voyager, astronomers see significant changes in Jupiter's cloud structure that have taken place over the past 12 years. To monitor the continuing evolution of the atmosphere, HST investigators will photograph the planet regularly during the next several years. These data will allow meteorologists to apply the sophisticated computer models used to forecast weather on Earth to the very different conditions on Jupiter. This, in turn, will help make those models more accurate and improve weather forecasts in the future.

Although the imaging team didn't plan it this way, when they photographed Jupiter, the planet's moon Europa was also in the field. You can see Europa right on the planet's eastern limb. In the closeups below the full disk image, Europa appears just off the limb (left, taken in blue light) and when it was half-hidden by Jupiter before passing behind the planet (right, in green light). Some very subtle surface features are visible on Europa and they seem to match features seen by Voyager, but they aren't distinct enough to see clearly.

Turning from the largest planet in the solar system to one of the largest stars in the Galaxy, HST zeroed in on Eta Carinae and the dusty nebula surrounding it (see page 48). Eta Carinae has long fasci-

by Richard Talcott





SWIRLS, SPOTS, AND BANDS dominate HST's first view of massive Jupiter. Also notice Europa partially hidden by the planet at right edge of the image; the photos at left give a closer look. All NASA photos; Europa closeup courtesy James Westphal.

nated astronomers, who witnessed an outburst in 1843 that for a time made the star the second brightest in the night sky. (It shone at magnitude –1 and trailed only Sirius.) During the outburst, Eta Carinae expelled great amounts of gas, creating an expanding nebula now known as the homunculus because it resembles a "little man."

This nebula is what HST imaged in unprecedented detail. (The star itself — a behemoth over 100 times more massive than the Sun — is hidden deep inside the nebula.) The most surprising discovery is that of a jet of material shooting away from Eta Carinae. The jet appears as two parallel lines — marking the edges of the jet — pointing to the northeast (upper left). At the tip of the jet you can see an inward-pointing, U-shaped structure. That's the bow shock created as the jet punches through the interstellar gas surrounding the star (in the same way a boat creates a bow wave as it plows through water).

The jet was totally unexpected. Similar jets are often seen around stars in the process of forming, but not in stars near the end of their lives, as Eta Carinae is thought to be. In young stars, jets seem to be confined by the disk of material from which the star is forming. Although a disk has been proposed to explain the elongation visible in the homunculus, that disk is rotated 90° from where it would have to be to explain the observed jet.

Several other fascinating features can be seen in the Eta Carinae image as well. Just to the left of the jet (and within the bow shock) is a strange ladder-like structure unlike anything seen before. A clear understanding of what causes this feature will take much more study. Small clumps of gas are likewise easy to see in the image. These clumps extend in size down to the limit of HST's resolution, which at Eta Carinae's distance of 9,000 light-years works out to about ten times the size of our solar system.

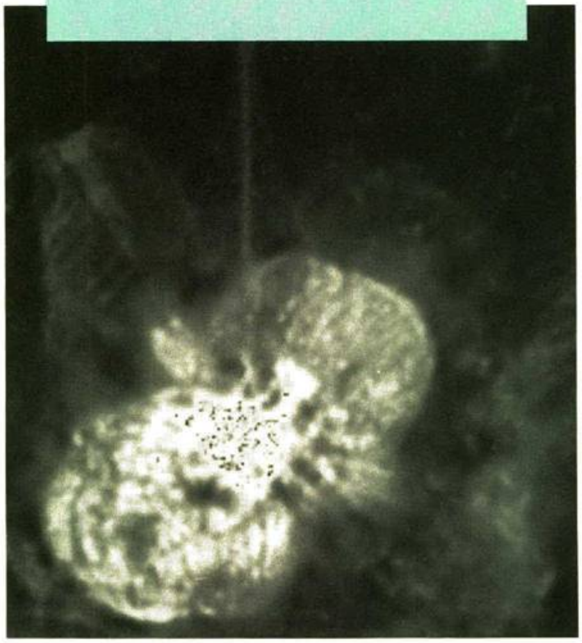
The two spectrographs on HST are also being kept busy. Two teams of researchers, one using the Goddard High Resolution Spectrograph and the other the Faint Object Spectrograph, have discovered hydrogen clouds in intergalactic space by studying quasar absorption lines. (See "A Quasar Lights Up the Universe" on page 42 for more details on this historic find.)

Closer to home, astronomers using the Goddard High Resolution Spectrograph have now obtained highly detailed spectra of the star Beta Pictoris. Astronomers' interest in Beta Pictoris really took off in 1983, when observations made with the Infrared Astronomical Satellite revealed that a large disk of solid particles surrounds the star. Later observations made with the International Ultraviolet Explorer satellite showed a smaller gas cloud around the star as well, and it was this cloud that the HST astronomers targeted with the spectrograph.

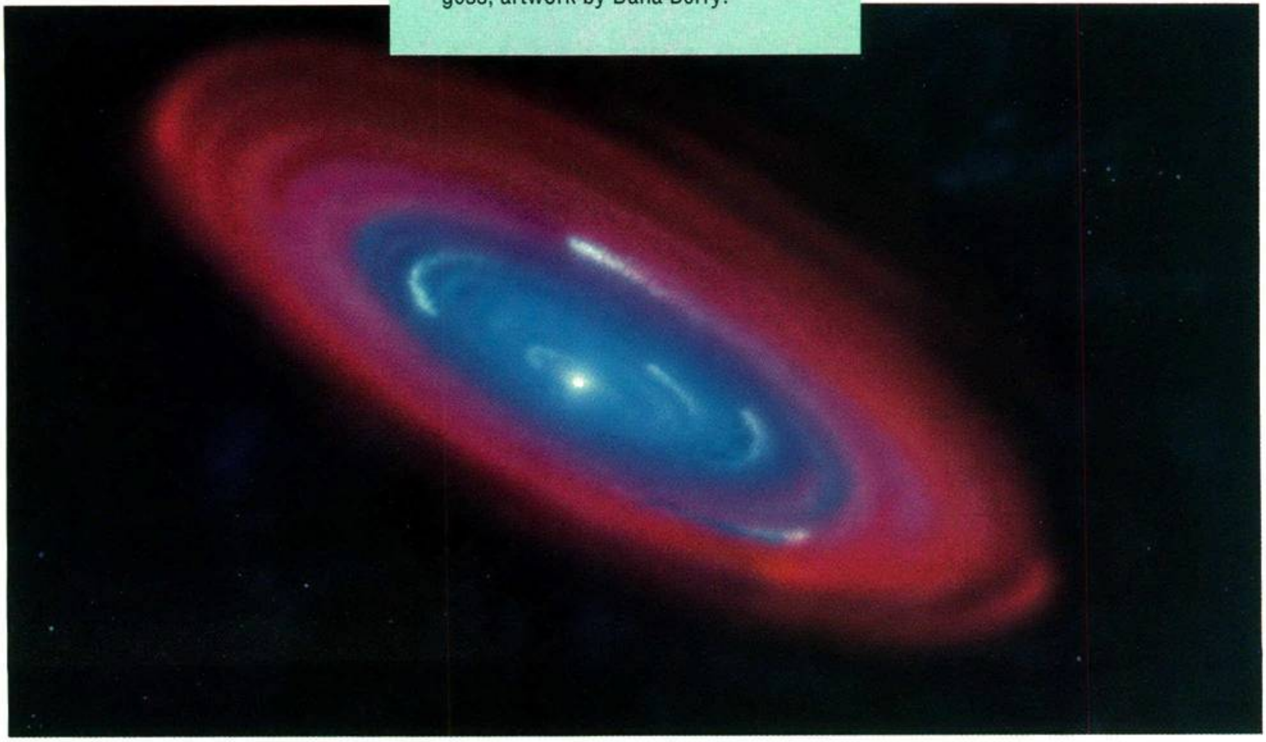
What they found surprised them: Over the course of just three weeks, the structure of the gas cloud changed significantly. The new picture of Beta Pictoris emerging from these studies is shown in the artwork below. Within the large disk of solid particles lies a gas cloud with many components. The outer region of the cloud (shown in red) is a disk of diffuse gas just a few astronomical units in diameter, about the size of the inner solar system, in a stable orbit about the star. Inside that is an inner gas disk (blue) drifting slowly toward the star. Clumps of gas in this region (the white condensations) are spiraling toward Beta Pictoris at speeds up to 200 kilometers per second (120 miles per second). And surrounding these three components is a large, tenuous cloud of gas that seems to be diffusing outward.

The inward motion of the innermost region means that the gas around Beta Pictoris cannot be a long-lived structure — either the gas must be continuously replenished or the inward flow must have arisen recently. Astronomers lean toward the former explanation, hypothesizing that the gas might come from the star's own stellar wind or from the decomposition of solid particles in the outer disk. It will take more HST observations to learn the truth. □

AFTERMATH OF AN EXPLOSION: The eruptive variable star Eta Carinae spews a jet of material to the northeast (upper left) while an associated bow shock and a bizarre ladder-like structure reside nearby. Jeff Hester/Caltech and NASA photo.



A GASEOUS DISK surrounds Beta Pictoris in this artist's concept. Some of the gas follows a stable orbit (red), some of it drifts slowly toward the star (blue), and some of it spirals into the star (white). Data courtesy Al Boggess; artwork by Dana Berry.



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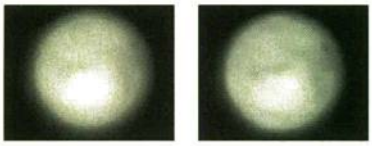

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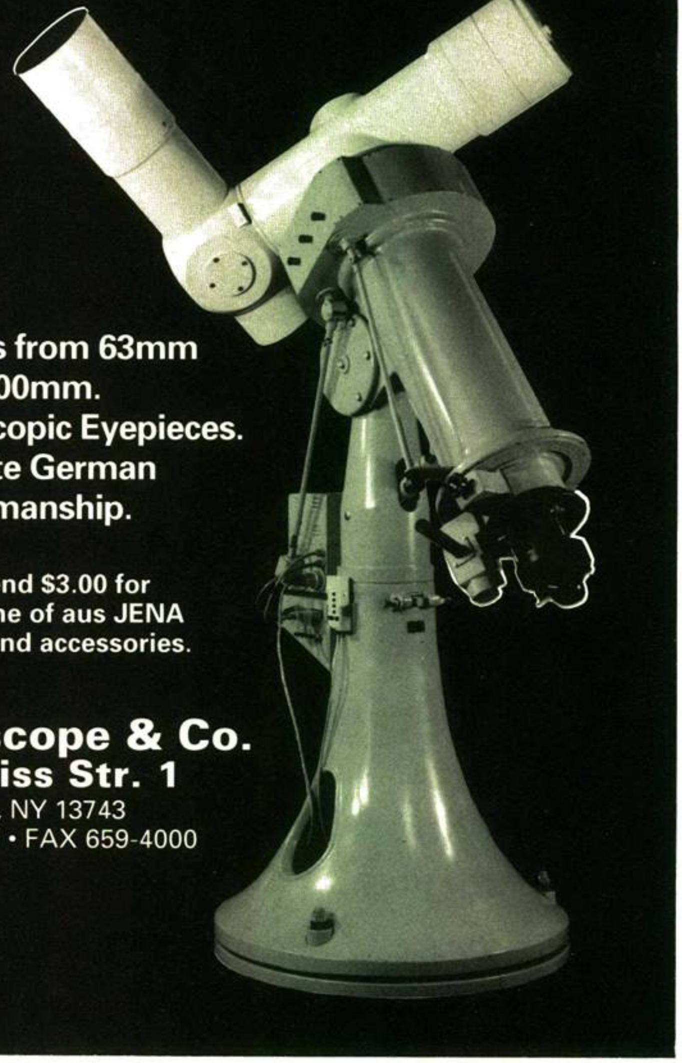

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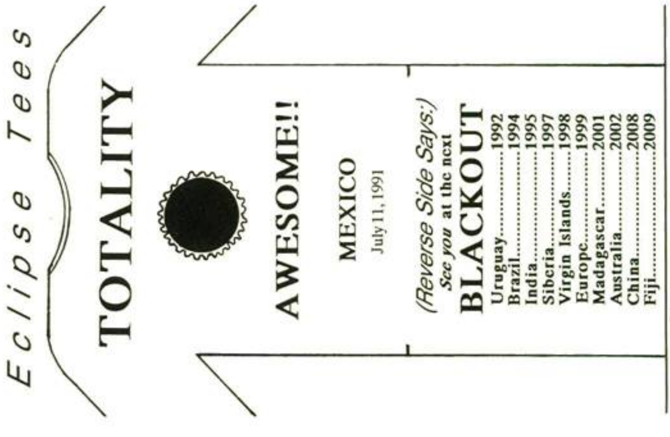
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COSMIC CATASTROPHIES

The End of CIVILIZATION?

Earlier this year an asteroid missed Earth by only 170,000 kilometers.
One day we won't be so lucky.

by Gerrit L. Verschuur

Usually, the headlines read "Dinosaurs Wiped Out by Asteroid." But the facts are not that certain. The sensational headlines hide a furious debate going on behind the scientific scenes. On one side are planetary astronomers, on the other paleontologists. Their debate boils down to this: Can extinctions of vast numbers of species be produced by a sudden, dramatic event, specifically a cosmic collision?

According to many planetary astronomers, the answer is an unequivocal yes. According to many paleontologists and geologists, the answer is no. They feel better evidence points to slow climate change or perhaps violent volcanic activity as the culprit.

But the question of whether the dinosaurs' demise can be linked to a single impact of an asteroid or comet is beside the point. The fact is asteroids *are* orbiting the Sun in paths that cross Earth's orbit, and one day one *will* hit, with disastrous consequences for life on Earth.

Theory with an Impact

Physicist Luis Alvarez and his colleagues at the University of California, Berkeley, began the debate over impacts in 1979 when they announced the discovery of a thin layer of iridium in a geological stratum. The layer they investigated was significant because it marked the boundary between the Cretaceous and Tertiary epochs, called the K-T boundary, a time of mass extinctions. It was the epoch 65 million years ago when the last of the dinosaurs died.

The iridium was also significant because it is rarely found on the surface of Earth. This is because iridium loves iron. (It is, in fact, called a siderophile.) When the early Earth was molten and the heavier elements were sinking to the center to form the iron-nickel core at the heart of our planet, the iridium clung to the iron and went along for the ride. Thus the Earth's crust became deficient in iridium. When Alvarez and his team discovered excess iridium in that ancient geological stratum, they knew that something special must have deposited the stuff 65 million years ago.

By the mid-1980s geologists had found evidence for iridium in the same clay layer all over the planet. So where did the iridium come from? The answer, at least for the Alvarez group, was space, from an asteroid at least 10 kilometers in diameter. The next question was whether such an impact could have caused the mass extinctions at the end of the Cretaceous period.

MILLIONS OF YEARS FROM NOW what evidence will alien archaeologists unearth about our civilization? As with the age of the dinosaurs, will our age be reduced to a layer of clay and ash marking the impact of an asteroid?

The impact theory immediately triggered an explosion of activity in the scientific community. There was a rush to understand mass extinctions. In 1987 paleontologist Steven M. Stanley of Johns Hopkins University wrote that the fervent efforts from paleontologists "resulted from our chauvinistic impulse to convince the world that astronomers do not have a simple answer to complex geological problems." Alvarez and friends had set the proverbial cat among the paleontological pigeons.

Catastrophes Make a Comeback

The impact theory prompted a revival in the idea of catastrophism — that sudden, short-lived events can affect the course of Earth's evolution. Such a revival runs counter to the traditional theories of "gradualism" that have dominated geology for over a century and a half (since Lyell's *Principles of Geology* was published in 1830).

The reason geologists and paleontologists have discounted catastrophes as an agent of change finds its roots in the last century when debate about catastrophism versus gradualism raged. The catastrophists lost, in part, because of the intellectual atmosphere created by a religious system that led people to believe that a metaphysical entity was in control of our destiny. A century ago it was difficult for anyone to believe that mass extinctions had even occurred. As Stanley has written, "Theology, more than anything else, fueled opposition to the idea of extinction. The biosphere was supposed to constitute a perfect creation, and the demise of entire species would imply imperfection."

If mass extinctions were difficult to swallow, what about catastrophes? How could God be so malicious as to visit a large-scale catastrophe upon his flock? Reinforcing the theological concern was an aspect of human nature that causes us to believe that we have some small degree of control over our lives. A catastrophic end to our individual existence was, and remains today, a notion we choose to deny, despite the fact that earthquakes, tornados, and cyclones take a toll of victims every year.

For philosophic and scientific reasons, gradualism became the accepted theory of geological change. Yet the evidence for catastrophic events in the solar system is everywhere. On Mercury and Venus, on the Moon, and on the surfaces of all the moons out to Neptune we see craters. Even Earth is pock-marked by impact craters. One need only look at the Barringer meteor crater in Arizona (1.2 kilometers in diameter), the Henbury crater in Australia (0.15 kilometers), the Ries structure in Germany (24 kilometers), or Lake Manicouagan in Quebec (100 kilometers) to see the evidence of collisions with asteroids. Today, 120 terrestrial impact craters have been identified and more are being added to the list each year. And this despite the fact that much of the evidence for craters has been lost to erosion or plate tectonics.

Nearly 100 Earth-crossing asteroids have been found so far, most of them in the last five years.

Eugene Shoemaker of the U. S. Geological Survey says that impacts are part and parcel of the phenomena that shape our planet. As he puts it, "The planetary scientists understand the role of impacts in sculpting the planet. That news has not filtered into the consciousness of the geological community." For example, only thirty years ago most geologists did not believe there were any impact craters on Earth. Then Shoemaker and his colleagues began to excavate in and around the Barringer crater and the Ries structure and found meteoritic material and fractured quartz to prove that they were formed by impact. Thirty years ago it was not yet certain that craters on the Moon were due to impact. Today no one questions that the vast majority of the craters on the Moon and other satellites and terrestrial planets of the solar system were caused by cosmic collisions.

As a result of the slow acceptance of the role of impacts, the catastrophism vs. gradualism debate still rages. The key issue in today's debate is not whether or not mass extinctions occurred but what the probable cause of those extinctions was. A hard-core group of paleontologists and geologists favors volcanic eruptions as the cause of mass extinctions. A more conservative group feels the explanation lies in slow, systematic change associated with climate variations linked to continental drift. Planetary scientists are convinced the weight of evidence is now stacked against both those views. They argue that we cannot ignore the fact we have always been subject to bombardment from space, a bombardment that continues to this day.

Paths That Cross in the Night

Just as paleontologists have been forced to reexamine the extinction records, planetary scientists have been driven to explore the skies more carefully. They uncovered the existence of a threat everyone had previously ignored, a threat brought home in March 1989 when an asteroid called 1989 FC brushed within 1,100,000 kilometers of Earth. In January 1991, an asteroid called 1991 BA passed only 170,000 kilometers from Earth, half the distance from Earth to the Moon. What should concern us most is not how close they came but the fact that no one saw either of these projectiles coming. Had either struck, it would have been devastating.

The spate of asteroids that astronomers have watched speed by Earth recently are all members of a band of Earth-crossing asteroids known as the Apollos. The largest of this family, Ganymed, (not to be confused with Ganymede, the moon of Jupiter) is 38 kilometers in diameter. No one knows the size of the smallest ones, though with a diameter of 10 meters, 1991 BA is the smallest found so far. If Ganymed were to collide with Earth, the impact would generate 50 times the energy of the K-T event and would effectively annihilate life on Earth. However, there is no indication that its orbit will place it and Earth in the same place at the same time during the foreseeable future.

According to Eugene and Carolyn Shoemaker and colleague Ruth Wolfe, nearly 100 Earth-crossing asteroids have been found so far, most of them in the last five years. At least 1,000 are suspected of lurking out there. About two thirds are stony "S-type" asteroids, with an average diameter of 900 meters. The other third are carbonaceous C-types, about 1,700 meters (1.7 kilometers) across. Their data suggest that the probability of a collision with a one-kilometer-diameter asteroid is about once in 250,000 years. Asteroid 1989 FC was smaller, between 100- and 400-meters across. Objects of that size will hit far more often. The problem is that no one knows how many of these smaller ones exist. Not yet at least.

Modeling Mayhem

What would happen if an Earth-crosser like 1989 FC actually struck Earth? John O'Keefe and Thomas Ahrens at Caltech have run computer models using asteroid 1989 FC traveling at 11 kilometers per second (24,500 miles per hour) relative to Earth, twice as fast as a speeding bullet. Their models show that the asteroid passes through the lower atmosphere in less than a second, not enough time for anyone in its path to see it coming. A shock wave is then driven into the ground and into the asteroid. The result: the asteroid is mostly vaporized, changing from solid to liquid to gas in a fraction of a second.

The explosion generates the energy equivalent of a 1,000 megaton bomb explosion and temperatures of 20,000° C. Hot gas from the vaporized object shoots into the sky and drags more air with it. A shock wave spreads away from the impact and everything within a hundred kilometers is set on fire from the heat of the blast. About 500 kilometers away the temperature is still a scalding 100° C.

The blast travels outward at 35,000 kilometers per hour and levels everything for 250 kilometers. Material from the impact rains down, mostly in the form of molten droplets of rock. A crater about ten times the diameter of the impactor is left behind. Asteroid 1989 FC has wiped out a city the size of New York in an instant.

Calculating the death and devastation from the impact of even a small asteroid staggers the mind. Given a range of uncertainty which can only be narrowed by experiments (avoidable ones, we hope), scientists at a 1981 conference on mass extinctions calculated that a collision with a 200-meter-diameter asteroid would produce a 1,000-megaton explosion and between 200,000 and 100 million deaths. Collision with a 400-meter-diameter object would produce a 10,000-megaton blast and between two million and one billion fatalities. And that is from an asteroid less than half a kilometer across.

H. J. Melosh and his colleagues at the University of Arizona have taken a close look at what would happen if a 10-kilometer-diameter asteroid, the size of the one suspected as the cause of the K-T extinctions, were to strike Earth. They found the plume of material ejected by the impact recondenses in space and showers down to cover Earth with debris. "At Earth's surface, the thermal radiation would be on the order of 10 kilowatts per square meter for as much as several hours after the impact," a power "comparable to that obtained in a domestic oven set to broil."

Ahrens and O'Keefe have modeled what would happen if that asteroid had struck a 5-kilometer-deep ocean, typical of most abyssal plains. A wave up to 5 kilometers high would be driven away from the point of impact. Fifteen hundred kilometers away the tsunami would still be 500 meters high. If such an asteroid were to hit the Gulf of Mexico, the waves would cause flooding in Kansas City!

Whether it hit land or ocean, the dust and soot raised by the impact would cut out sunlight for months on end. The result, according to a small team of atmospheric scientists led by Richard Turco of R&D Associates in Marina Del Rey, California, would be a long "impact winter" lasting for as much as 1,000 years. During such a period of drastic climate change, large numbers of species would be wiped out.

Impact winter is but one consequence of a collision with a large asteroid. The plume that rises into the atmosphere will also carry a wide variety of chemicals that will produce extended periods of acid rain, so much that the acidity of the oceans would destroy marine life, a typical symptom of a mass extinction that tends to take a relatively greater toll in the oceans than on land.

Did such a devastating impact do in the dinosaurs? No one knows for sure. However, even if scientists do not yet agree on whether the death of the dinosaurs or other mass extinctions was caused by collisions, volcanos, or climate change, we must confront the fact that the swarm of Apollo asteroids and the craters on the Moon and on Earth tell us that an asteroid impact is inevitable. According to Clark Chapman of the Planetary Sciences Institute in Tucson and David Morrison of NASA Ames in California, a major asteroid impact is expected once in about 300,000 years. Does that mean such an impact is tens of thousands of years away? Not necessarily. Since it would not take a massive impact to wipe out our civilization, the fateful day could be sooner than you think.

For example, an impact from even a small asteroid might do little more than disrupt the ecosystem for a few years. Yet such a "minor" event could destroy civilization. Why is this? Because civilization depends on the exploitation of natural resources, including the agricultural resources we rely upon to feed the world's population. If our food supply is totally disrupted, as it would be in the case of an impact winter, crops would die all over the world. The fragile strands of civilization would quickly unravel. Our species, if not driven to extinction, would be decimated, driving survivors into a stone-age existence.

What Can We Do?

Should we lose sleep over any of this? No. But we should do something. Unlike most natural disasters, an asteroid impact can be forestalled — *if* we see it coming. And therein lies a dilemma.

Only a handful of people are keeping a look out — mostly Eugene Shoemaker, his wife Carolyn, and a few volunteers. It was one of Shoemaker's volunteer assistants, Henry Holt, who spotted 1989 FC, and then only in photographs processed several days after the asteroid had passed Earth. Not much upon which to rest the future of civilization, is it?

As another of that small band who spend their professional careers searching for asteroids, Eleanor Helin of the Jet Propulsion Laboratory in Pasadena points out that there is widespread disregard for such studies, even though the future of life on Earth may depend on our awareness of where such objects are.

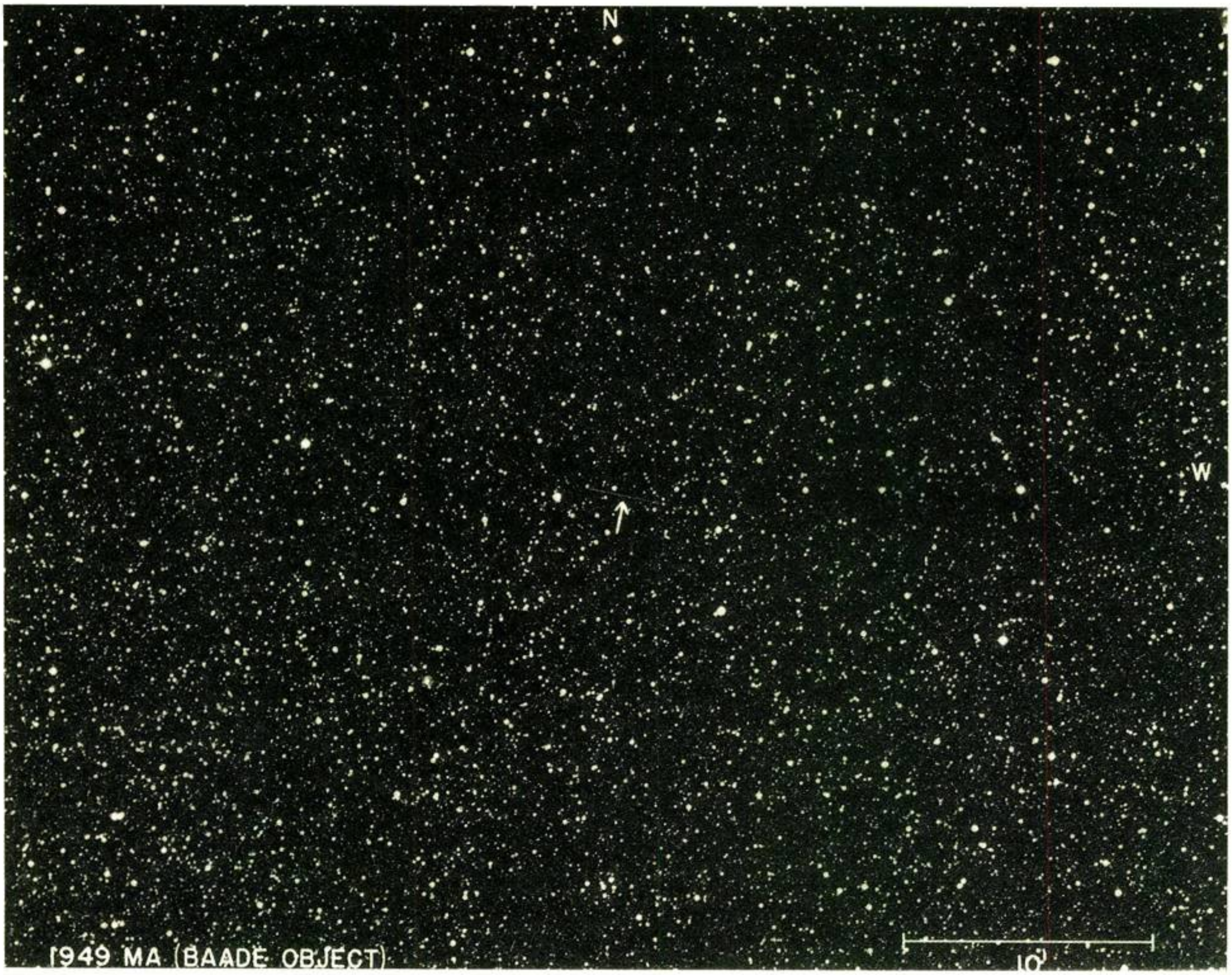
The total cost of the project would be about $20 million, a small price to pay for the first step in assuring the survival of civilization.

A small-scale Spacewatch project is going on now at Kitt Peak National Observatory where Tom Gehrels and Jim Scotti are using a 36-inch Newtonian equipped with a CCD camera telescope to scour the skies. However, we need to expand the search effort. We need to act on an international level by investing a small amount for a few 36-inch Schmidt telescopes. Eugene Shoemaker estimates that using about four such telescopes spread around the planet, 90 percent of the 1,000 or so dangerous Earth-crossing asteroids would be found within 10 years. The total cost of this international Spacewatch project would be about $20 million over ten years, a small price to pay for the first step in assuring the survival of civilization.

What if we discover an oncoming asteroid that threatens Earth? We cannot move Earth out of the path of the asteroid but we can redirect the course of a mindless rock. In a study called Project Icarus, engineers at MIT examined this scenario. Their scheme calls for flying to the asteroid and placing an explosive charge on its surface (perhaps a nuclear bomb). The rocket action of the explosion will change the course of the asteroid. Contrary to Hollywood's movie version of the plan, it will not be a good idea to shatter the object — Earth would then be struck by a hail of projectiles rather than a single blast.

What Should We Do?

So are we prepared to do this? Of course not, mostly because the idea has only recently been suggested. With any problem of so vast a scope, we find it difficult to take the threat seriously. Planetary scientists have only just begun to argue convincingly that the threat exists, and engineers have only a preliminary plan



to deflect an asteroid from an Earth-shattering course. This program should be developed and be made an integral feature of our space program, at least if we want to make sure our species survives well into the future.

In their quest for knowledge, scientists have now discovered a sword of Damocles hanging over our heads in the form of Earth-crossing asteroids. It is time to confront this threat to our continued survival, a threat that could cost the lives of tens of millions of people in the first second of impact and trigger the death of billions more within days or weeks. How do we drive home the reality of this danger to national governments? Is it even possible? Aren't the threats of the ozone hole and global warming bad enough? Yes, these may all be more immediate but nevertheless we, as a youthful technological society, must recognize the existence of the asteroid threat.

In summary, the debate over the fate of the dinosaurs, though still being argued, has forced our attention on an inevitable fact of life. The Earth *has* been struck repeatedly by large objects from space and it will be struck again. We need to take the message of the craters and the Earth-crossers seriously.

It is human nature to ignore the greatest threats that confront us. This syndrome is widespread in the volcanically active zones of the world. We refuse to accept that we, as individuals, will suffer in the next catastrophe. This is why so many people can live quite happily astride the San Andreas fault or in the shadow of an active volcano. But it would be a tragedy of unimaginable proportions if the human race were a collective victim of this syndrome, if we allowed ourselves to be wiped out because we were unwilling to face what scientists have learned during the last decade. In the words of the environmental movement, we must think globally and act locally to take charge of our destiny. It now appears necessary that we also think cosmically and act globally because there lurks a threat that will otherwise eliminate civilization from the face of the planet.

True, seen from a cosmic perspective, humankind counts for little. The universe does not exist for our benefit and asteroids pay no heed to our planet or anything that may dwell upon its surface. But isn't civilization and human life on Earth worth preserving? The universe may not think so, but I for one do. ☐

"WHEN WORLDS COLLIDE," the classic science fiction movie of the 1950's, may have been inspired by this tiny object. The faint streak marks the trail of Icarus, an Earth-crossing asteroid that made headline news over 40 years ago. This image is the discovery photo of Icarus taken from Palomar Mountain in 1949 by Walter Baade.

Gerrit L. Verschuur is a radio astronomer and author living near Bowie, Maryland. His last article for ASTRONOMY *was "The Southern Radio Sky Comes to Light," April 1991. In 1978 he published a book entitled* Cosmic Catastrophes, *now out of print, and is currently working on a planetarium show with the same title, to be produced by the Hansen Planetarium in Salt Lake City with a grant from the National Science Foundation.*

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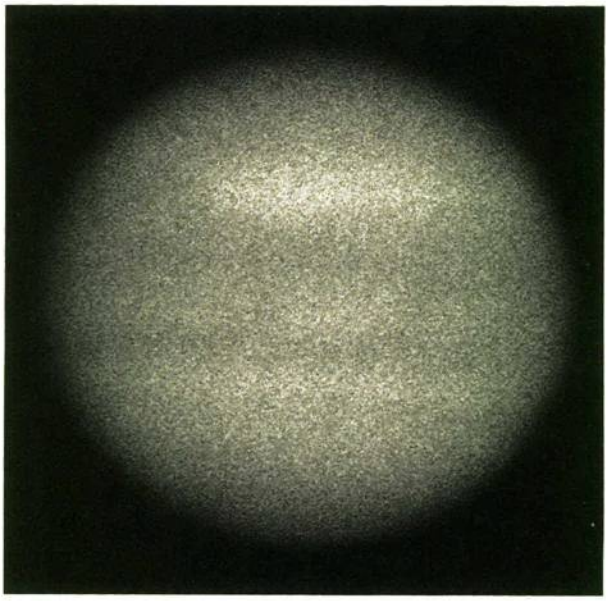
Could be Jupiter.



Could be a pita.

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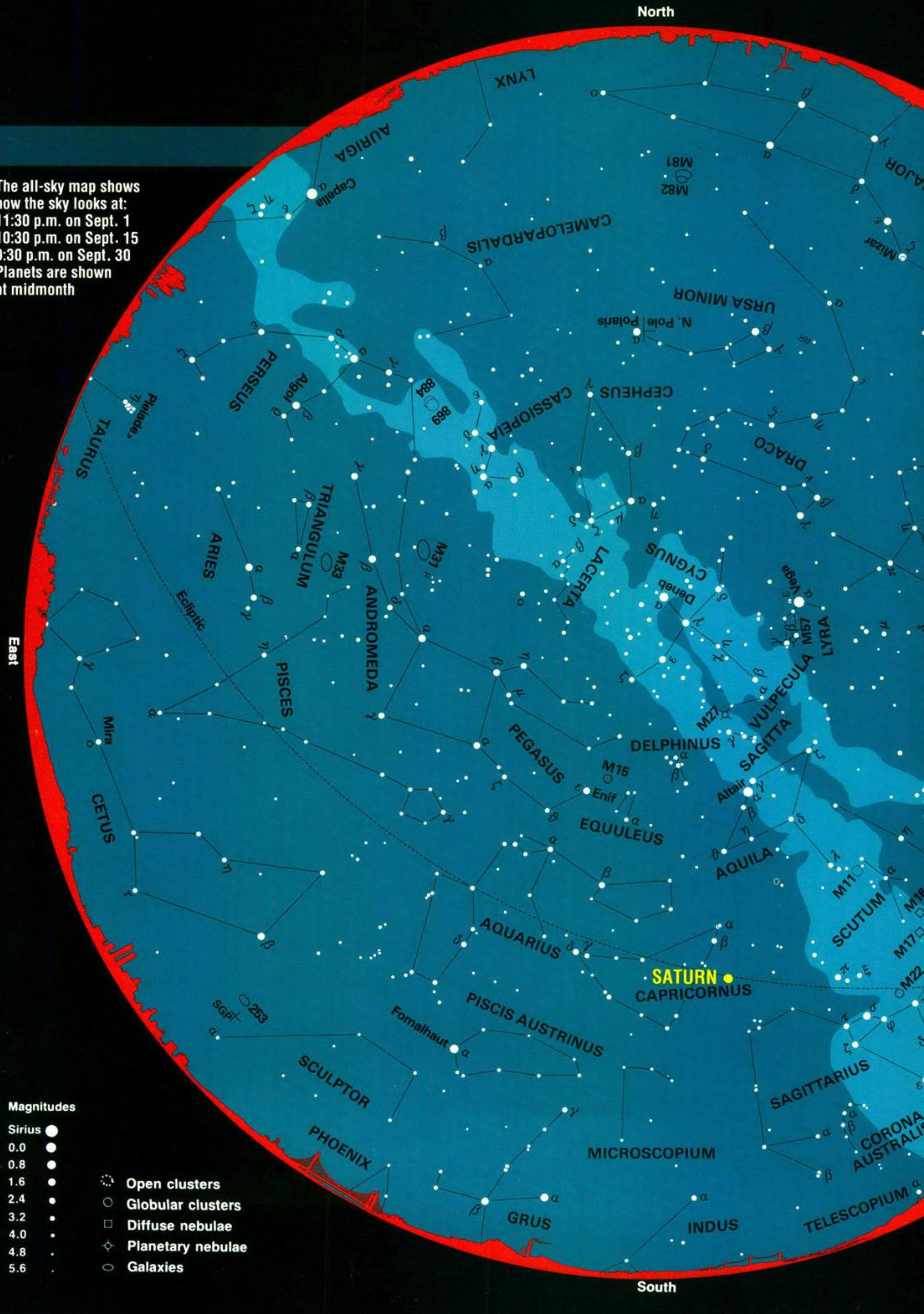
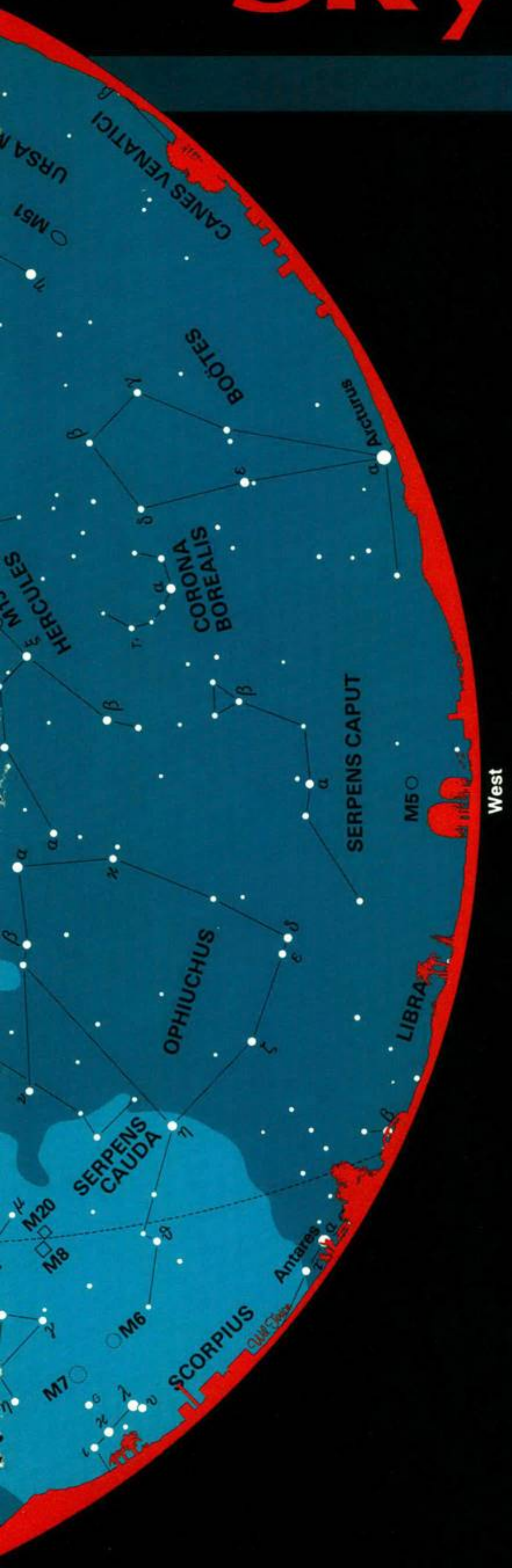
The all-sky map shows how the sky looks at:
11:30 p.m. on Sept. 1
10:30 p.m. on Sept. 15
9:30 p.m. on Sept. 30
Planets are shown at midmonth


North
East
South
LYNX
AURIGA
Capella
CAMELOPARDALIS
M81
M82
URSA MINOR
N. Pole
Polaris
Mizar
PERSEUS
Algol
Pleiades
TAURUS
CASSIOPEIA
869
884
CEPHEUS
DRACO
TRIANGULUM
M33
M31
ARIES
ANDROMEDA
LACERTA
CYGNUS
Deneb
Vega
M57
LYRA
Ecliptic
PISCES
VULPECULA
M27
DELPHINUS
SAGITTA
Mira
PEGASUS
M15
Enif
Altair
CETUS
EQUULEUS
AQUILA
M11
SCUTUM
M16
M17
AQUARIUS
SATURN
CAPRICORNUS
M22
SGP
253
PISCIS AUSTRINUS
Fomalhaut
SCULPTOR
SAGITTARIUS
CORONA AUSTRALIS
PHOENIX
MICROSCOPIUM
GRUS
INDUS
TELESCOPIUM
Magnitudes
Sirius
0.0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
Open clusters
Globular clusters
Diffuse nebulae
Planetary nebulae
Galaxies

Sky Almanac

September 1991



AN UNFORGETTABLE ENCOUNTER

As Jupiter and Regulus rise in tandem out of the twilight glare in early September, they meet Mercury just as that planet reaches the peak of its morning apparition. The three naked-eye objects are closest to one another on the morning of September 10, when they are separated by 0.4°.

VENUS AT GREATEST BRILLIANCY

Slightly higher in the east than the tantalizing trio of Mercury, Jupiter, and Regulus lies the brightest planet of all, Venus. Venus shines at its brightest for the year on September 28/29, when it glows at magnitude –4.6.

COMET HARTLEY 2 AT PERIHELION

Perhaps the brightest periodic comet of 1991 will be Comet Hartley 2, which reaches perihelion on September 16/17. It is well-placed in the morning sky for telescopic observations throughout the first half of September, when it is expected to shine at 9th or 10th magnitude.

Calendar of Events

1 Last Quarter Moon is at 2:16 p.m. EDT

5 The Moon is at perigee (226,590 miles from Earth), 3:29 p.m. EDT

6 The Moon passes 5° north of Venus, 1 p.m. EDT

7 The Moon passes 3° south of Mercury, 1 a.m. EDT
The Moon passes 5° south of Jupiter, 7 a.m. EDT
Mercury is at greatest western elongation (18°)

8 New Moon is at 7:01 a.m. EDT
Asteroid Iris is at opposition

10 Jupiter passes 0.4° north of Regulus, 4 a.m. EDT
Mercury passes 0.07° south of Jupiter, 6 a.m. EDT
Mercury passes 0.3° north of Regulus, 6 a.m. EDT

11 Asteroid Bamberga is at opposition
Venus is stationary

15 First Quarter Moon is at 6:01 p.m. EDT

17 Comet Hartley 2 is at perihelion
The Moon is at apogee (251,246 miles from Earth), 11:23 a.m. EDT

19 The Moon passes 1.8° north of Saturn, midnight EDT

23 Autumnal equinox is at 8:48 a.m. EDT
Full Moon is at 6:40 p.m. EDT

28 Venus is at greatest brilliancy (–4.6 magnitude)

30 Last Quarter Moon is at 8:30 p.m. EDT

A MORNING GATHERING OF PLANETS

This month offers an opportunity to see something rare and wonderful in the sky. Two bright planets and a bright star are tightly clustered low in the east before dawn. The planets are Jupiter and Mercury. The star is Regulus, the "heart of the Lion," in the constellation Leo. They all appear near one another for some days, though they are closest on September 10.

Look for these objects no later than 30 minutes before the Sun rises. At that time, they're slightly more than 10° above the eastern horizon as seen from throughout the United States and Canada. They're close enough to the Sun that they wouldn't be visible at all, if not for the steep angle of the ecliptic — the path of the Sun, Moon, and planets across the sky — relative to the eastern horizon in the morning at this time of year.

If you want to see the planets when they are closest, pray for a transparent sky on the morning of September 10. The least haze or cloudiness low in the sky will obscure the view. Find a site with an unobstructed eastern horizon and begin scanning for the trio about 45 minutes before dawn (binoculars will make your search much easier). Mercury, Jupiter, and Regulus will lie shimmering in the morning twilight in an almost straight north-south line only about 21' long. Mercury and Jupiter are only 3' apart as seen from the eastern United States on the 10th. To the naked eye, they may appear as one. By the time dawn comes to the Hawaiian Islands, the two planets have moved 16' apart. Notice the contrasting colors of the planets and the star. And marvel at this rare and gorgeous alignment.

VENUS PEAKS IN BRIGHTNESS

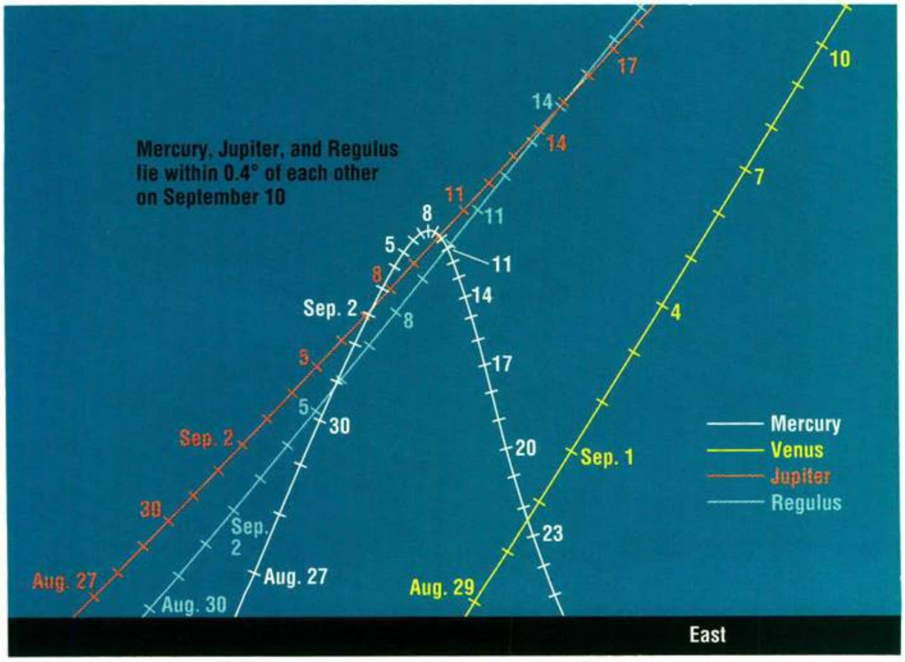
Venus rises about half an hour before the grouping of planets and Regulus on September 10. For some days around then, while that trio performs an intricate dance low in the predawn sky, Venus hovers above them and to their right. It lies only 12° away.

Only the Sun and Moon shine more brightly than Venus. Its "greatest brilliancy" for this morning apparition, and indeed for the entire year, takes place on September 28/29. The planet then shines at magnitude –4.6.

Greatest brilliancy always happens when Venus is near us in space. The planet passed between Earth and the Sun last month and is now only slightly ahead of us in its smaller and faster orbit. Through a telescope, the disk of Venus looms large. A telescope also reveals that the planet is in a crescent phase. This crescent Venus appears brighter to us than the fuller Venus we see at other times, simply because the planet is closer and its disk appears so big.

A HARVEST MOON ON THE EQUINOX

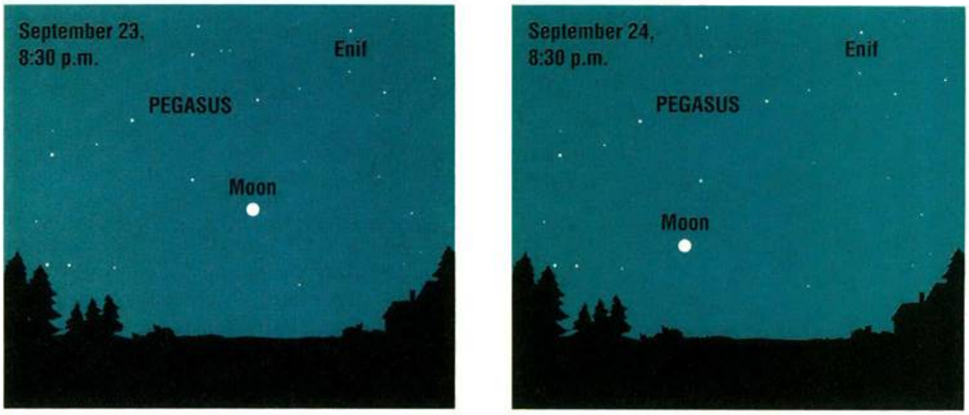
The September equinox takes place at 8:48 a.m. EDT on September 23. The Moon is full only about 10 hours later. There's no question about it — this is the Full Moon closest to the September



A QUARTET OF BRIGHT OBJECTS graces the morning sky in early September, but the month's outstanding event occurs when three of them — Mercury, Jupiter, and Regulus — appear within a hair's breadth of one another on the 10th. Look for the trio 10° above the eastern horizon 30 minutes before sunrise.

equinox. Therefore, it's known as the Harvest Moon.

The fame of the Harvest Moon stems from the brief lag in moonrise from one night to the next. Throughout most of the year, the Moon rises about 50 minutes later each day. In the autumn, however, the Full Moon comes over the horizon only about half an hour later each day. This change is brought to us by the shallow angle the ecliptic now makes relative to the eastern horizon in the evening. From one day to the next, the Moon's eastward motion around Earth doesn't take the Moon that much farther below the horizon. Thus, for several days in a row, there's no long period of darkness between sunset and moonrise. Before the days of farm machines equipped with lights, the light of the full Harvest Moon aided farmers bringing in their crops.



IT'S HARVEST TIME AGAIN, as the full Harvest Moon shines down on early evening activities in late September. The Harvest Moon is famous because it rises only 30 minutes later each night and its elevation at a given time changes little from one evening to the next.

Modern stargazers will enjoy viewing and even drawing the position of moonrise relative to foreground objects for several evenings around this Full Moon. The Moon rises substantially farther north each evening. What's more, since this year's Harvest Moon comes so close to the equinox, the Full Moon rises nearly due east, while the Sun sets due west, on the evening of September 23.

SEPTEMBER'S PLANETS

Saturn lies in the south-southeast when night begins and sets before the Sun returns at dawn. It is a gentle golden light among the much fainter stars of the constellation Capricornus. Saturn shines at magnitude 0.4 this month. Although it fades slightly during the month, it remains prominent.

The eerie, brilliant beacon in the east before dawn is the brightest planet, Venus. When September begins, Venus rises about an hour before the Sun, but by month's end, it's up more than three hours before sunrise. At greatest brilliancy on September 28/29, the planet shines at magnitude –4.6.

Mercury reaches greatest western elongation on September 7. It is then low in the east before dawn, 18° from the Sun on the starry dome. On that same morning, Mercury, Jupiter, and Regulus lie above and to the left of the slim crescent Moon. Mercury shines at magnitude –0.2 at this time. It appears closest to Jupiter and Regulus on the morning of September 10.

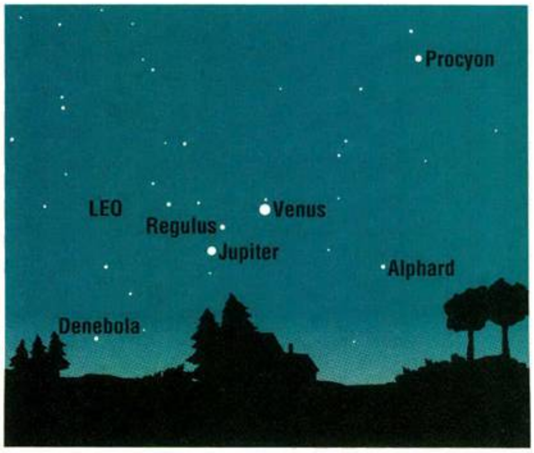
Jupiter, which lies in Leo, emerges in the east before dawn in early September. It stays within 12° of Venus all month. Although it is the second-brightest planet at magnitude –1.7, Jupiter still pales in comparison to brilliant Venus. Following the close grouping of Jupiter, Mercury, and Regulus on September 10, Jupiter and Regulus ascend into the predawn sky while Mercury drops into the Sun's glare after mid-month.

Mars can be glimpsed very low in the west about half an hour after sunset in early September. Then the Red Planet disappears into the Sun's glare, not to return until 1992.

THE STARRY SKY

Turn your gaze southward some evening this month, and you'll see the golden planet Saturn. Saturn is now located among the background stars of the constellation Capricornus, the Sea-Goat. Although this constellation is fairly faint, it is clearly visible in a dark sky. The

THE BRILLIANT BEACON in the east before dawn this month is Venus, which shines at its brightest for the year on the morning of September 29.



first person to point it out to me identified it as an arrowhead, and I've seen it that way ever since.

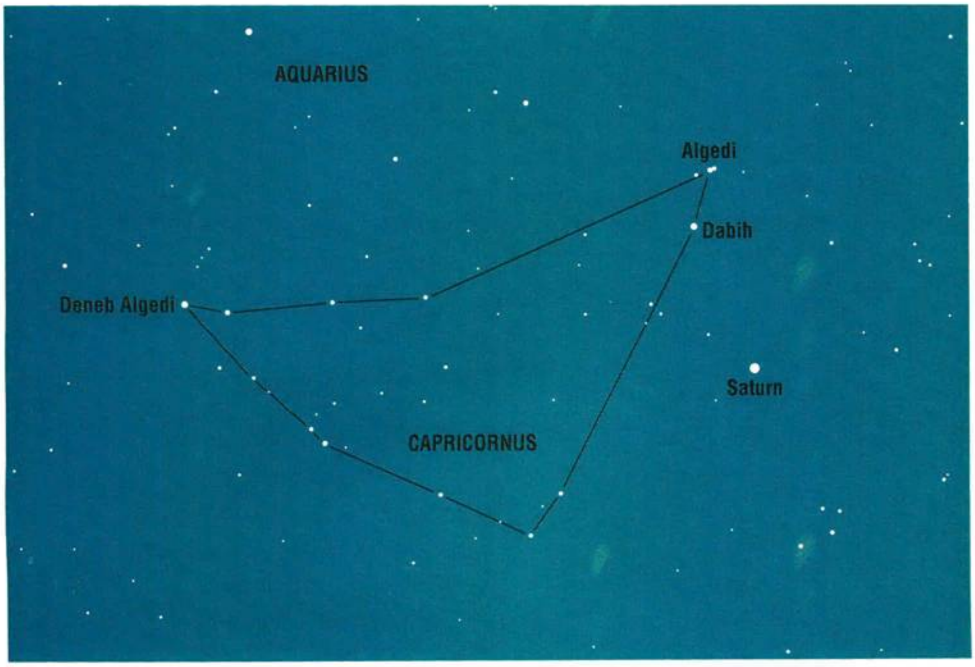
Capricornus is one of twelve zodiacal constellations. The Sun, Moon, and all the planets pass through its boundaries as they move across the sky. Some say Capricornus represents Pan, the ancient god of herds and flocks. Pan had the body of a man, but the horns, ears, and legs of a goat. It's said that Pan once jumped into a river when frightened by a giant called Typhon. Pan's lower body was transformed into that of a fish. To commemorate this event, the other gods placed the Sea-Goat among the stars.

Capricornus inhabits a celestial "ocean," which spreads across the heavens at this time of year. Early stargazers believed there was a connection between events in the vault of heaven and natural phenomena on and near Earth. They were aware that the Sun passed in front of particular stars each year during the rainy season. As a result, they designated constellations in that region of the sky as "watery." Capricornus the Sea-Goat, Pisces the Fish, Aquarius the Water-Carrier, and Cetus the Whale all occupy this ocean in the autumn sky.

Capricornus is next door to Sagittarius, a star-rich region of the heavens located toward the center of the Milky Way. Capricornus isn't crowded with stars, though. It's a relatively uncluttered constellation, with some easy pickings for beginning stargazers.

First look for Alpha Capricorni, which also goes by the name of Algedi the Goat. It is a wide optical double, which you can "split" or see as two stars with the naked eye. The brighter star of the pair is 3.6-magnitude Alpha^2. The fainter star is 4.2-magnitude Alpha^1. Although these stars may look related, they're located at very different distances from Earth. Alpha^2 is a bit over 100 light-years away; Alpha^1 is more than ten times farther. Both stars have companions visible through small telescopes, making this pair one of the sky's "double-doubles."

About 2° southeast of Alpha is Beta Capricorni, another wide double star. Some observers claim to have "split" this pair, whose magnitudes are 3.4 and 6.2, with the naked eye. It's easy to see the two stars through binoculars. Beta has the proper name of Dabih. Its two components are gravitationally bound and located about 100 light-years away.



CAPRICORNUS, THE SEA-GOAT, rides high in the south on September evenings. Use the bright planet Saturn, just west of Capricornus, as a guide to finding this zodiacal constellation.

Before taking leave of Capricornus, don't miss Delta Capricorni, or Deneb Algedi, which is located in the tail of the Sea-Goat. On the night of September 23, 1846, the German astronomer John Galle was conducting an intense search in Delta's vicinity, a search based on calculations made independently by John Couch Adams in England and Urbain Leverrier in France. In what is still considered to be one of history's greatest mathematical achievements, Galle turned the telescope just northeast of Delta Capricorni and discovered the planet Neptune. □

Deborah Byrd is the creator of "Star Date," an independently syndicated daily radio series on commercial and public radio.

Through the Eyepiece *by* Jeff Kanipe

PLANETS PARLEY IN THE PREDAWN SKY

Those of you who enjoyed the series of planetary conjunctions in the evening sky this summer will want to rise early in September, as three of the planets reassemble in the eastern sky before dawn. This is an opportune time to observe these planets because their telescopic appearances are changing rapidly.

Undoubtedly, one of the more eye-catching configurations will be the tight little grouping comprised of two of those planets, Mercury and Jupiter, and the bright star Regulus. You'll find the group low in the east about half an hour before the Sun rises.

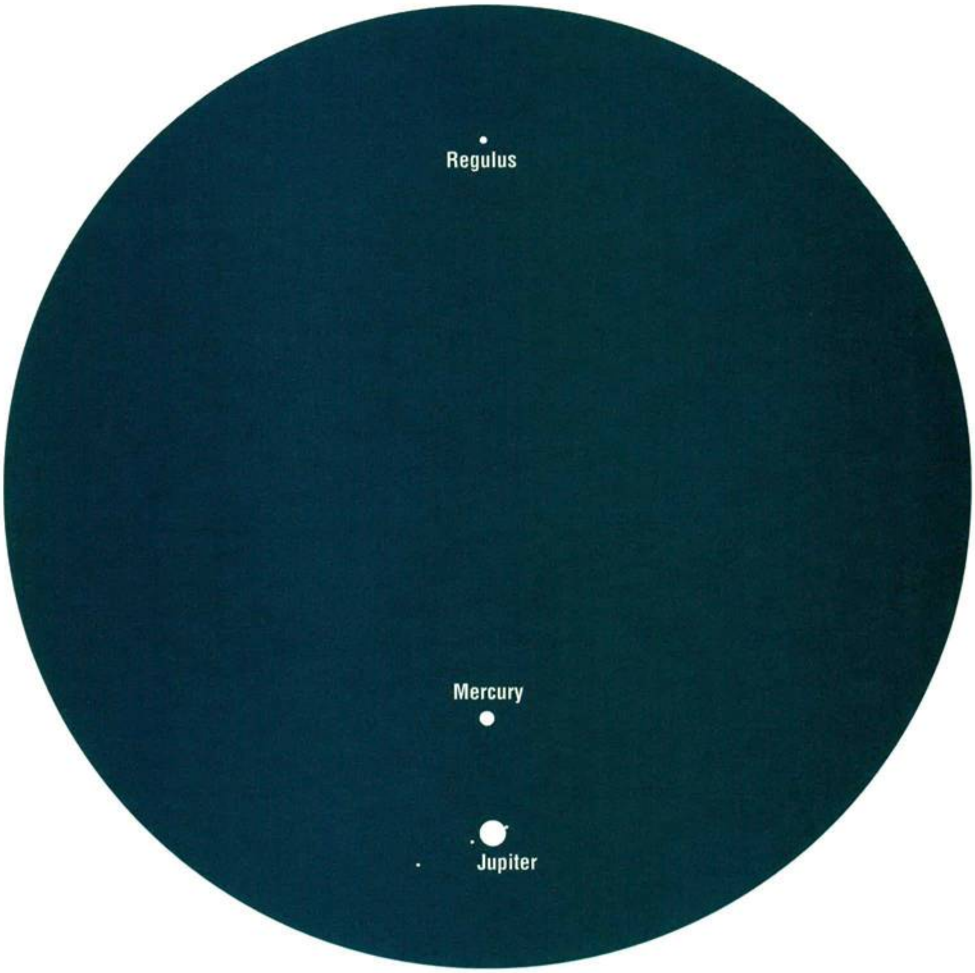
The most exciting telescopic view comes just before sunrise on September 10, when Mercury passes just 0.3° north of Regulus and 0.07° south of Jupiter — a rare grouping you should be sure not to miss! On that morning, observers using telescopes at moderate magnification can fit all three objects into a single field of view. As you look upon the scene, imagine that you are looking at mileposts marking both interplanetary and interstellar space: At the time, Mercury is about 90 million miles away, while Jupiter lies 500 million miles beyond that. Regulus, though, is a million times more distant still — an 85-light-year leap that takes you into the sparse northern realm of the Galaxy. Beyond lie only a handful of stars and then intergalactic space.

THE PHASES OF MERCURY

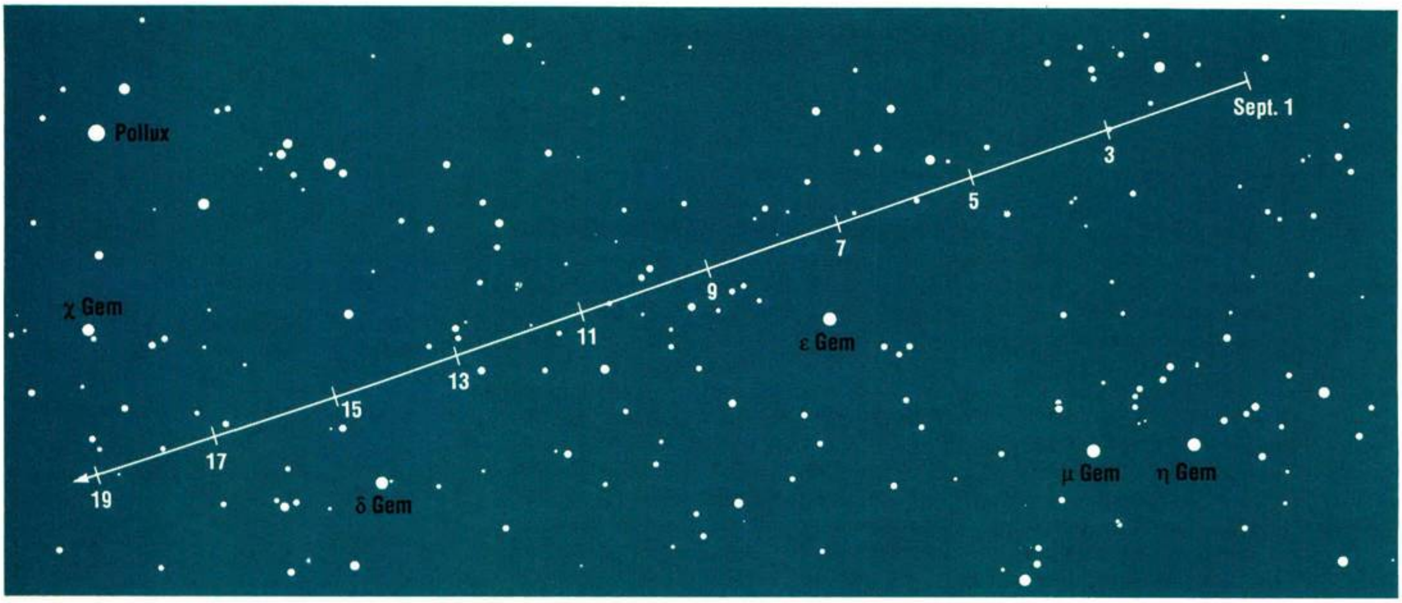
The planets' movements with respect to the Sun and Earth this month set the stage for some entertaining changes in appearance, which you can follow quite easily with a telescope.

Mercury finally puts in a good appearance for Northern Hemisphere observers this month, having graced the skies in more southerly latitudes through much of our summer. The innermost planet shines at magnitude 1.3 on September 1 (the same brightness as Regulus), but brightens considerably by the middle of the month. Having passed through inferior conjunction in mid-August, Mercury now lies west of the Sun as seen from Earth. It moves farther west of the Sun and climbs higher in our morning sky, until it reaches greatest elongation on September 7, after which it sinks back toward the Sun.

Over the course of the month, an observer using at least a 3-inch refractor and fairly high magnification can watch Mercury's phase grow rapidly while its disk shrinks in size. On September 1, the planet shows a disk measuring 8.9" across that is just 18-percent lit. By September 21, the planet's disk has shrunk to 5.3" in apparent diameter while the slim crescent has waxed to a 91-percent-lit gibbous phase.



VIEW THE DAZZLING TRIO of Mercury, Jupiter, and Regulus on the morning of September 10. This scene shows what East Coast observers will see at 6 a.m. EDT as viewed at 135x (south is at top). From farther west, Mercury and Jupiter will appear farther apart and the Jovian satellites will change relative positions.



COMET HARTLEY 2 should shine at 9th or 10th magnitude during the first half of September, when it can be found among the background stars of Gemini. Positions are shown for 5 a.m. EDT (4 a.m. CDT, 3 a.m. MDT, 2 a.m. PDT).

COORDINATES FOR COMET HARTLEY 2

Date	R.A. (2000)	Dec.
Sep. 1	6h08.1m	29°07'
Sep. 3	6h20.1m	28°26'
Sep. 5	6h31.8m	27°42'
Sep. 7	6h43.1m	26°55'
Sep. 9	6h54.0m	26°07'
Sep. 11	7h04.4m	25°16'
Sep. 13	7h14.5m	24°25'
Sep. 15	7h24.3m	23°32'
Sep. 17	7h33.6m	22°39'
Sep. 19	7h42.7m	21°45'

JUPITER: A DIFFERENT ANIMAL

Because it is a great deal farther from the Sun than Mercury, giant Jupiter moves more slowly in its orbit. Hence it will remain in Leo for the rest of the year, while Mercury zips through Leo and forges into Virgo by the end of September. Even though Jupiter is now at its faintest for the year, the –1.7-magnitude planet is a beacon for those searching for Mercury, given their proximity to one another.

Over the next few months, Jupiter brightens as it climbs higher in the morning sky. Like Mercury, it is worth observing in the twilight glow. The morning air, especially calm, provides steadier images well after sunrise. The colors, belts, and cloud details on Jupiter stand out because they don't have to compete with a dazzlingly bright surface, as seen at night. The equatorial belts appear as dark gray bands; the rest of the disk is mottled with browns and grays.

When the seeing is steady and you can use fairly high magnification, Jupiter is exciting to observe because you never know what you'll see. Its ever-changing cloud features, for example, are intriguing. Some of them are quite pretty; others are pretty unusual. Even with a small telescope, many of these features are quite easy to see. Look for ephemeral white ovals in the tropical regions, deep blue festoons in the equatorial zone (thought to be rifts in Jupiter's upper cloud deck) and, of course, the Great Red Spot, which quite often changes in shape and intensity. Something always seems to be happening on Jupiter!

DOES VENUS GLOW IN THE DARK?

While in the vicinity, take a look at the third of the morning planets, Venus. It's the radiant "star" lying above and to the right of Mercury and Jupiter. Like Mercury, Venus recently emerged from inferior conjunction and now lies just west of the Sun's glare. On September 1, a telescope at moderate magnification shows Venus as an extremely thin crescent with an apparent angular diameter of 56". The planet's phase waxes to 28-percent lit by the end of the month, while its apparent size shrinks to 37" across over the same period. Venus also grows brighter during the course of the month. Its magnitude increases from –4.2 on the 1st to –4.5 on the 15th, and on the 28/29th it peaks at magnitude –4.6. Venus is then at greatest brilliancy and appears brighter than at any other time this year.

Venus' slim crescent phase makes this a good month to try looking for the mysterious "ashen light." Since the telescope's invention in the 17th century, observers occasionally have reported seeing a copper-colored glow on Venus' night side during the planet's crescent phase just after inferior conjunction. According to observers' reports, the entire hemisphere sometimes appears to glow, while at other times only a small area is affected. So what's going on? Volcanic activity? Atmospheric phosphorescence? Global aurorae?

Actually, the phenomenon may be nothing more than a visual contrast effect between the planet's bright and dark sides. After all, most ashen-light observations are reported when Venus is in its crescent phase, and the contrast is then greatest. In any case, the ashen light is rare and difficult to see. Once you see it — *if* you see it — you'll have to decide for yourself.

COMET HARTLEY 2 RETURNS

One of the brightest short-period comets this year is visible in early September. You might think that Comet Hartley 2, with a period of only 6.3 years, is a frequent visitor to the inner solar system, and you would be right. But nobody knew it existed until March 1986, when it was discovered by astronomer Malcolm Hartley in Siding Spring, Australia, as it was heading away from the Sun. This year is the comet's first *predicted* return. The orbit, astronomers think, is a new one for this comet, probably "engineered" by an encounter with massive Jupiter in the early 1980s.

Hartley 2 has been moving across the morning sky and growing slowly brighter throughout the summer. It is expected to reach 9th or 10th magnitude at its brightest in September. The comet reaches perihelion on September 16/17, when it lies just inside Earth's orbit, but it is well north and west of the Sun at the time and thus fairly well-placed for observing. Use the map or table of coordinates on the opposite page to locate Comet Hartley 2.

ASTEROIDS IN THE EYEPIECE

A pair of 8th-magnitude asteroids come to opposition within a few degrees of each other this month. First is 7 Iris, which reaches opposition on September 8, and next is 324 Bamberga on September 11. The tables of coordinates and map at right will get you to the asteroids' approximate positions near where Aquarius, Pisces, and Pegasus meet. Zero in on those regions with a medium-power eyepiece and look for the two "stars" that don't belong. To confirm your sightings of the asteroids, photograph or sketch the two fields and then return to the same regions the following night. The two points of light that have moved slightly are Iris and Bamberga. ☐

A former associate editor of ASTRONOMY, Jeff Kanipe is the editor of Star Date *magazine, which is published by McDonald Observatory at the University of Texas at Austin.*

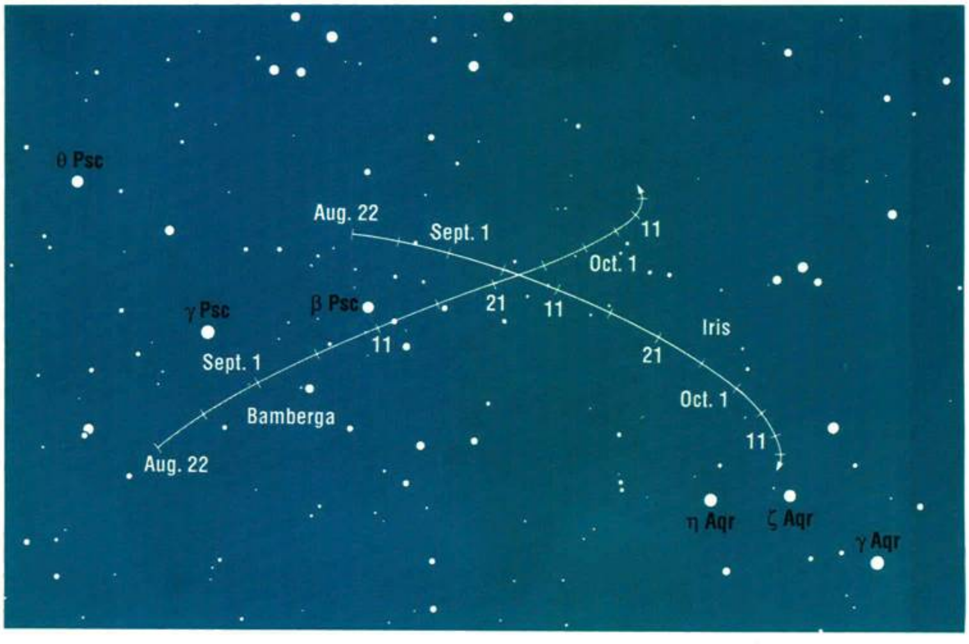
COORDINATES FOR IRIS

Date	R.A. (2000)	Dec.
Aug. 22	23h05.3m	5°20'
Aug. 27	23h01.5m	5°12'
Sep. 1	22h57.2m	4°57'
Sep. 6	22h52.7m	4°38'
Sep. 11	22h48.2m	4°13'
Sep. 16	22h43.8m	3°45'
Sep. 21	22h39.8m	3°14'
Sep. 26	22h36.2m	2°43'
Oct. 1	22h33.4m	2°12'
Oct. 6	22h31.2m	1°42'
Oct. 11	22h30.0m	1°14'
Oct. 16	22h29.6m	0°50'

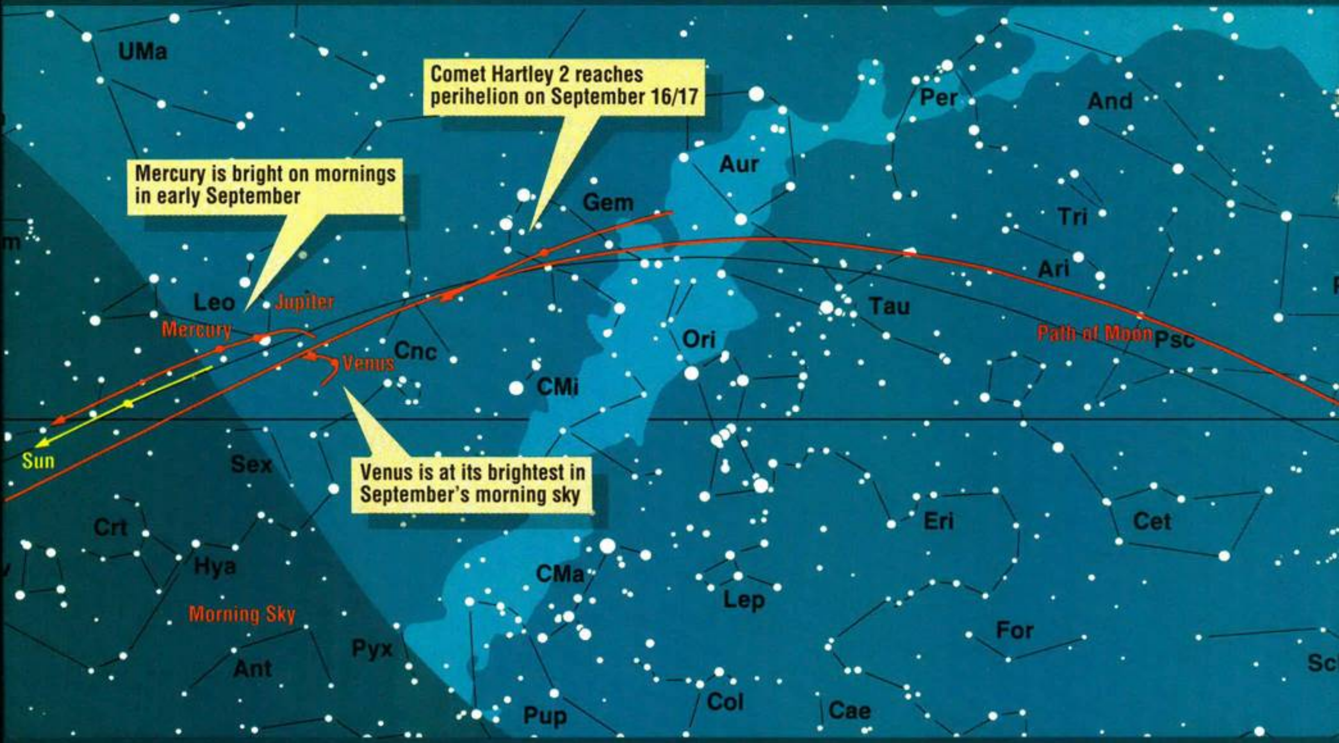
COORDINATES FOR BAMBERGA

Date	R.A. (2000)	Dec.
Aug. 22	23h21.3m	0°52'
Aug. 27	23h17.4m	1°34'
Sep. 1	23h13.0m	2°14'
Sep. 6	23h08.1m	2°50'
Sep. 11	23h03.1m	3°23'
Sep. 16	22h58.1m	3°53'
Sep. 21	22h53.5m	4°19'
Sep. 26	22h49.4m	4°44'
Oct. 1	22h46.0m	5°06'
Oct. 6	22h43.4m	5°27'
Oct. 11	22h41.8m	5°47'
Oct. 16	22h41.2m	6°07'

CRISSCROSSING ASTEROIDS Iris and Bamberga share the area near where Pisces, Aquarius, and Pegasus all meet. Positions are shown for 11 p.m. EDT (10 p.m. CDT, 9 p.m. MDT, 8 p.m. PDT).



The Solar System September 1991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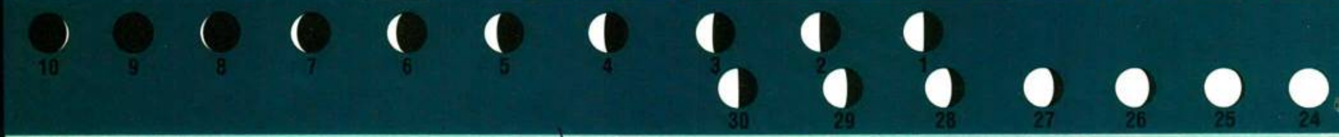
Comet Hartley 2 reaches perihelion on September 16/17

Mercury is bright on mornings in early September

Venus is at its brightest in September's morning sky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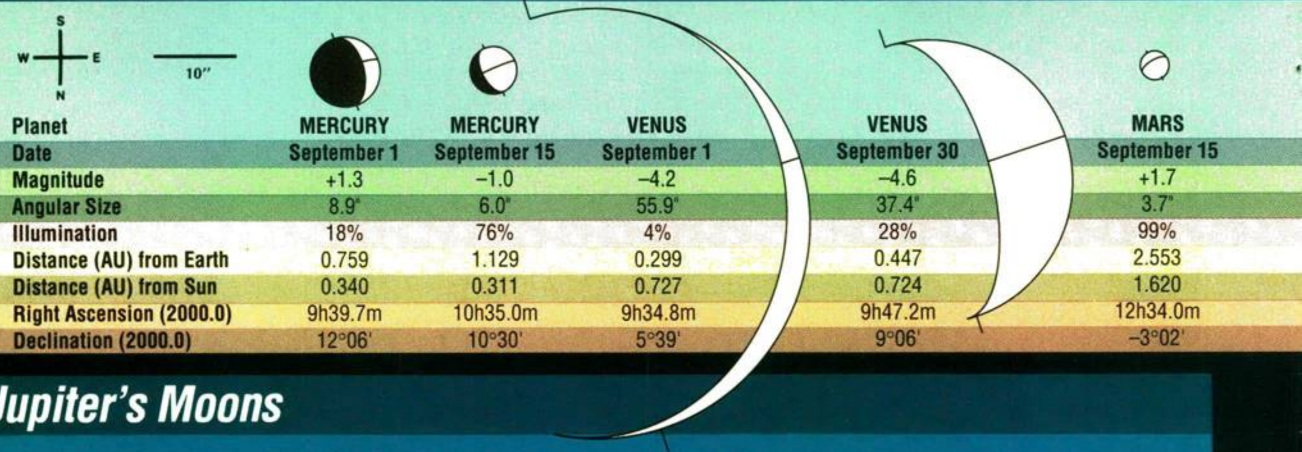
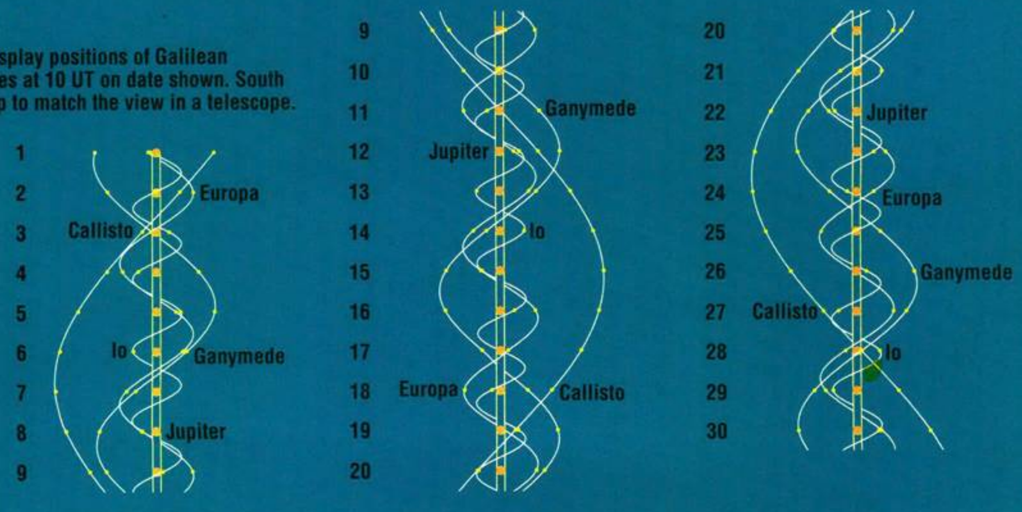
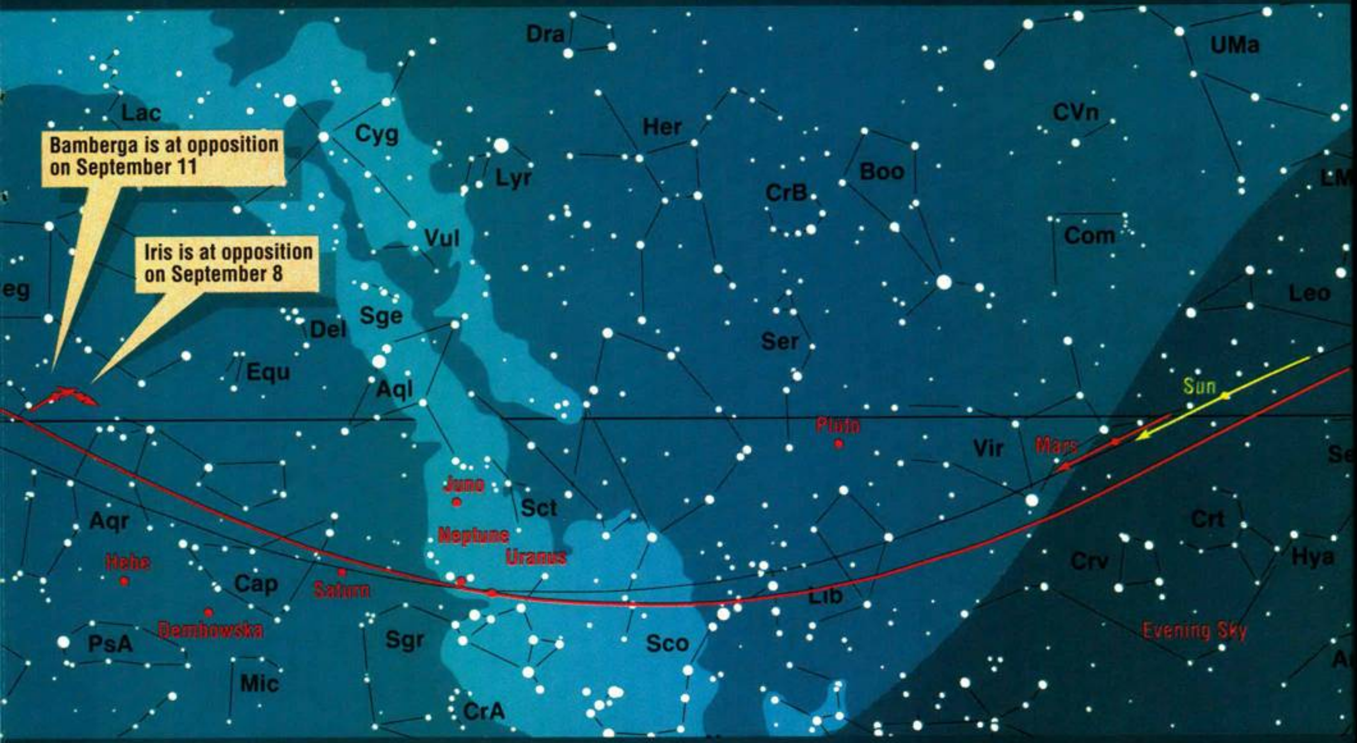


Planet	MERCURY	MERCURY	VENUS	VENUS	MARS
Date	September 1	September 15	September 1	September 30	September 15
Magnitude	+1.3	−1.0	−4.2	−4.6	+1.7
Angular Size	8.9″	6.0″	55.9″	37.4″	3.7″
Illumination	18%	76%	4%	28%	99%
Distance (AU) from Earth	0.759	1.129	0.299	0.447	2.553
Distance (AU) from Sun	0.340	0.311	0.727	0.724	1.620
Right Ascension (2000.0)	9h39.7m	10h35.0m	9h34.8m	9h47.2m	12h34.0m
Declination (2000.0)	12°06′	10°30′	5°39′	9°06′	−3°02′

Jupiter's Moons

Dots display positions of Galilean satellites at 10 UT on date shown. South is at top to match the view in a telescope.




Bamberga is at opposition on September 11

Iris is at opposition on September 8

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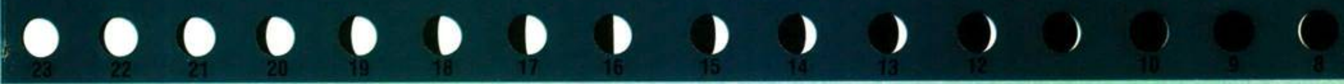
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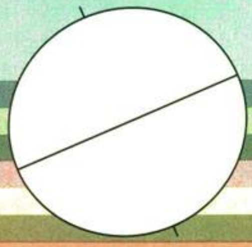
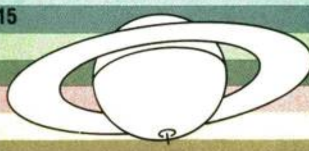
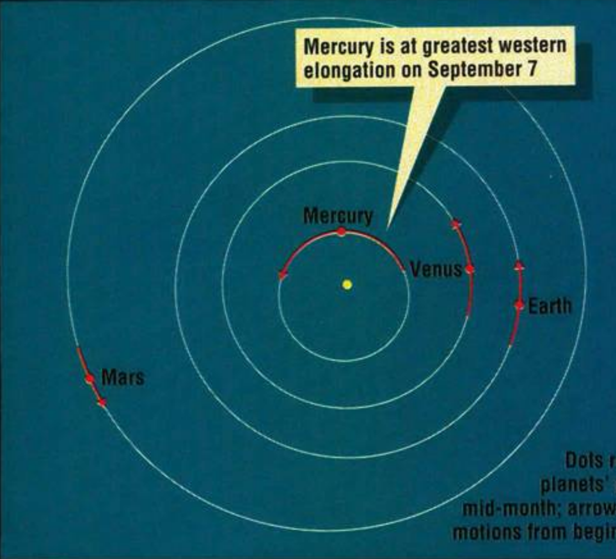


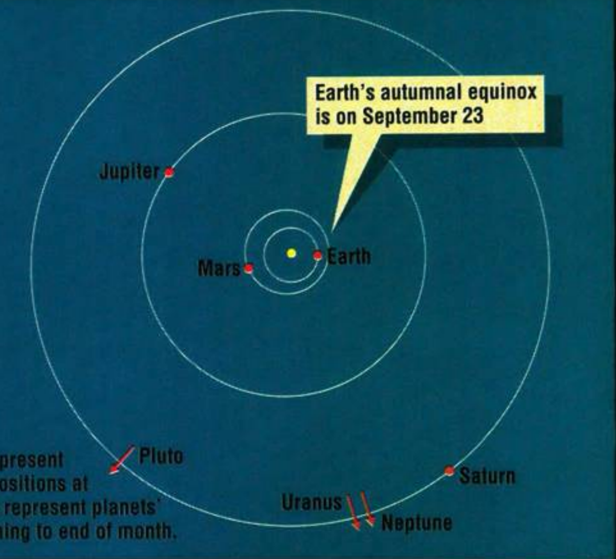


JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
September 15	September 15	September 15	September 15	September 15
−1.7	+0.4	+5.7	+7.9	+13.8
31.3"	17.8"	3.7"	2.2"	0.1"
100%	100%	100%	100%	100%
6.287	9.293	19.153	29.800	30.204
5.361	9.954	19.490	30.197	29.680
10h12.2m	20h11.8m	18h43.4m	19h01.0m	15h19.6m
11°59'	−20°32'	−23°27'	−21°55'	−3°06'

The Planets in Their Orbits


Mercury is at greatest western elongation on September 7

Mercury
Venus
Earth
Mars


Earth's autumnal equinox is on September 23

Jupiter
Mars
Earth
Pluto
Saturn
Uranus
Neptune

Dots represent planets' positions at mid-month; arrows represent planets' motions from beginning to end of month.

The Fall Football and the Game of Astronomy

You want to be an instant astronomer? To discover the sky, walk outside this autumn and look up.

by John Mood

On crisp autumn evenings, my observing sessions usually end around midnight, after five or six hours of viewing. What signals the end of the session, other than my own fatigue, is that a great asterism of six bright stars, the Winter Circle, has risen in the east. It is a pretty sight, appears unusually large because it is near the horizon, and reminds me of the outstanding viewing of the winter wonders that will be mine in a few months.

The Fall Football

Because we first see the Winter Circle in the autumn — during pigskin season — and because it is not really a circle but rather elliptical in shape, my wife has taken to calling it the Fall Football. Sirius and Capella constitute its two ends. It is perhaps a little overinflated in comparison with the sleek passing models used by the pros, but with the stitching of Orion's Belt near one edge, it does look remarkably like a football.

Whatever you want to call it, the Fall Football gets noticed by everyone, even those new to astronomy, because it is so large and made of such bright stars. To all of us, novice and veteran alike, it heralds the glories of the winter skies, cul-minating in M42, the Orion Nebula. We all love to return again and again to those marvelous celestial sights. But the Fall Football is only the start of a great autumn observing evening. Some of the stars in and around the Fall Football are in fact among the closest stars in the sky, and they can be viewed with the naked-eye or binoculars. Additionally, some these stars are beautiful doubles when viewed with a small telescope. To begin with, consider that five of the eight closest naked-eye stars lie within 80° of each other in this part of the sky. You don't need optical aid to find the highest ones either — only the simple star map opposite.

Watching the Closest Stars

Let's take these bright naked-eye stars in order from east to west. First is lovely Procyon, a very pale yellowish jewel. It is the fifth nearest naked-eye star. Next comes Sirius, the brightest star in the sky and the second nearest naked-eye star system. Procyon and Sirius are both easy to find because of their brilliance.

The next two stars lie close together in the dim constellation Eridanus the River. These stars are easy to locate because of the distinctive bends in the river beginning at Orion's knee and meandering down to the southern horizon. First is Omicron^2 Eridani, also known as 40 Eridani, visible at magnitude 4.5. It is the eighth nearest naked-eye star system. Next is Epsilon Eridani, which can be found a few degrees farther west. This star is slightly brighter than Omicron^2 at magnitude 3.7 and the third closest naked-eye star. Finally, if you move over to the constellation Cetus you can easily discover Tau Ceti, a sun glowing at magnitude 3.5. It is the seventh nearest naked-eye star.

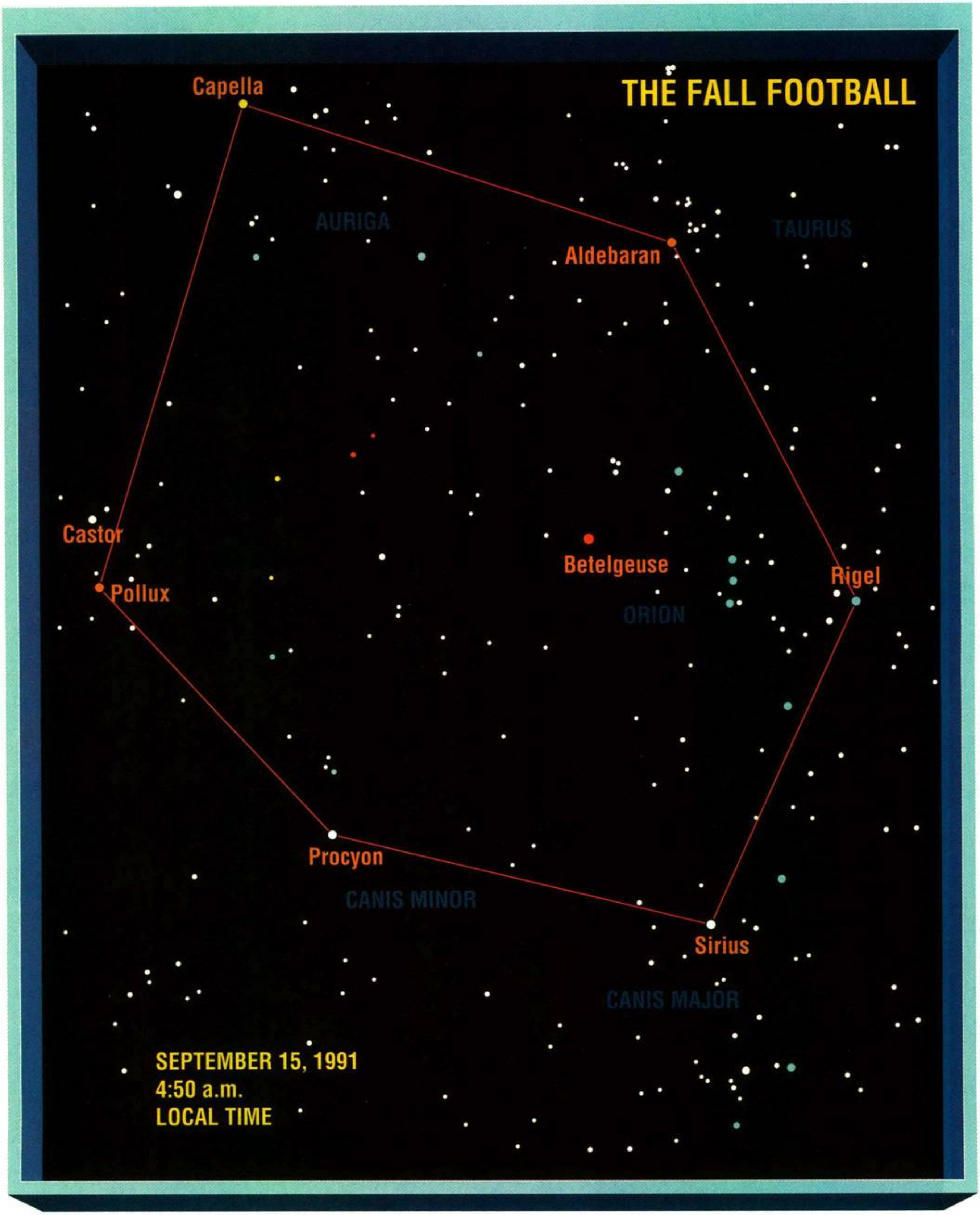
Now that you have found them, the next step is to view them in order of closeness, remembering as you do so that you are in effect traveling outward in space. As your eyes swing back and forth across this quadrant of the sky, the order they will follow is from Sirius over to Epsilon Eridani, then east to Procyon, back west to Tau Ceti, and ending in the middle again with Omicron^2 Eridani.

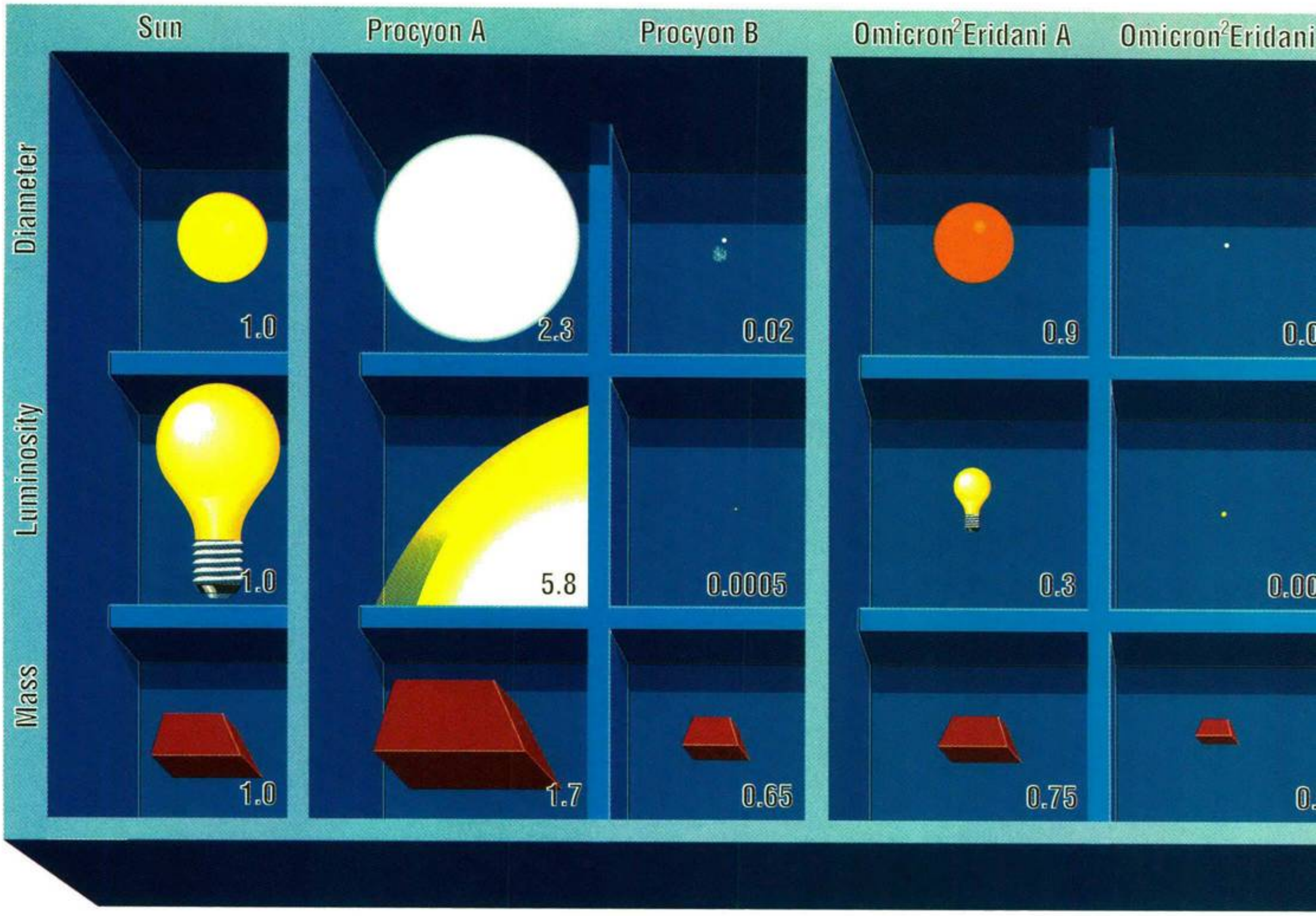
A Closer Look at the Neighbors

Go again to gleaming-white Sirius, a spectral class A star almost too bright to look at. Only 8.7 light-years away, Sirius can nearly ruin your eye's adaptation to the dark. Some night turn off your scope's clock drive, place Sirius outside the field of view of your eyepiece, and watch it come into view with a spectacular series of spikes and colors. If the viewing is exceptionally good and you have a 10-inch or larger scope, you might try spotting Sirius B, the dim and extremely close white dwarf companion.

Following the order of increasing distance, next move your scope to Epsilon Eridani, a single K class star 10.8 light-years away. Then move back to Procyon, a slightly whiter star of spectral class F only 11.3 light-years distant. Like Sirius, Procyon has a white dwarf companion, but Procyon's secondary star is so

BRIGHT NAKED-EYE STARS are visible in a unique way when you observe autumn's Fall Football asterism. Five of the eight closest naked-eye stars lie in this part of the sky. Diagram by Thomas L. Hunt.


THE FALL FOOTBALL
Capella
AURIGA
Aldebaran
TAURUS
Castor
Pollux
Betelgeuse
ORION
Rigel
Procyon
CANIS MINOR
Sirius
CANIS MAJOR
SEPTEMBER 15, 1991
4:50 a.m.
LOCAL TIME


Sun
Procyon A
Procyon B
Omicron²Eridani A
Omicron²Eridani
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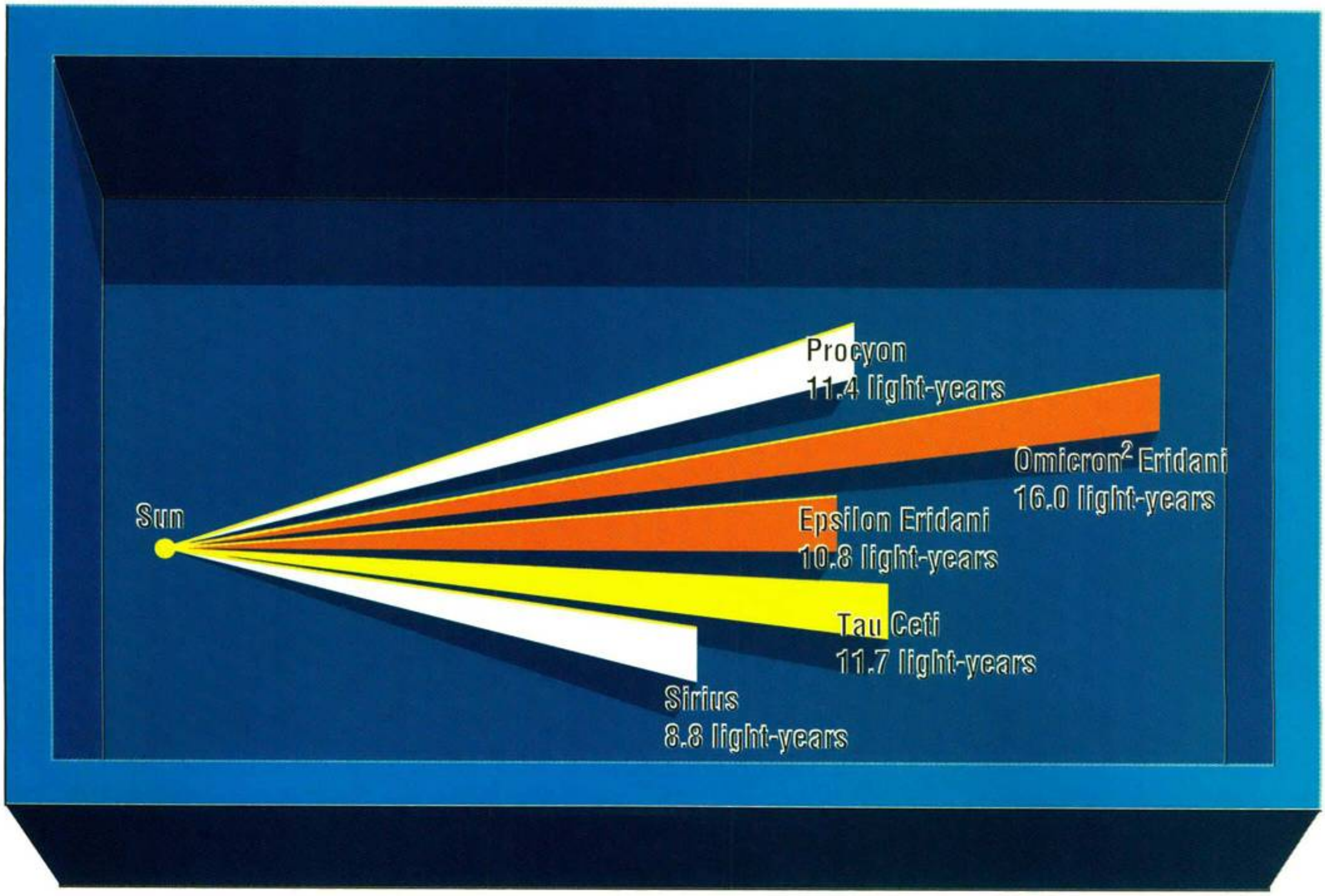
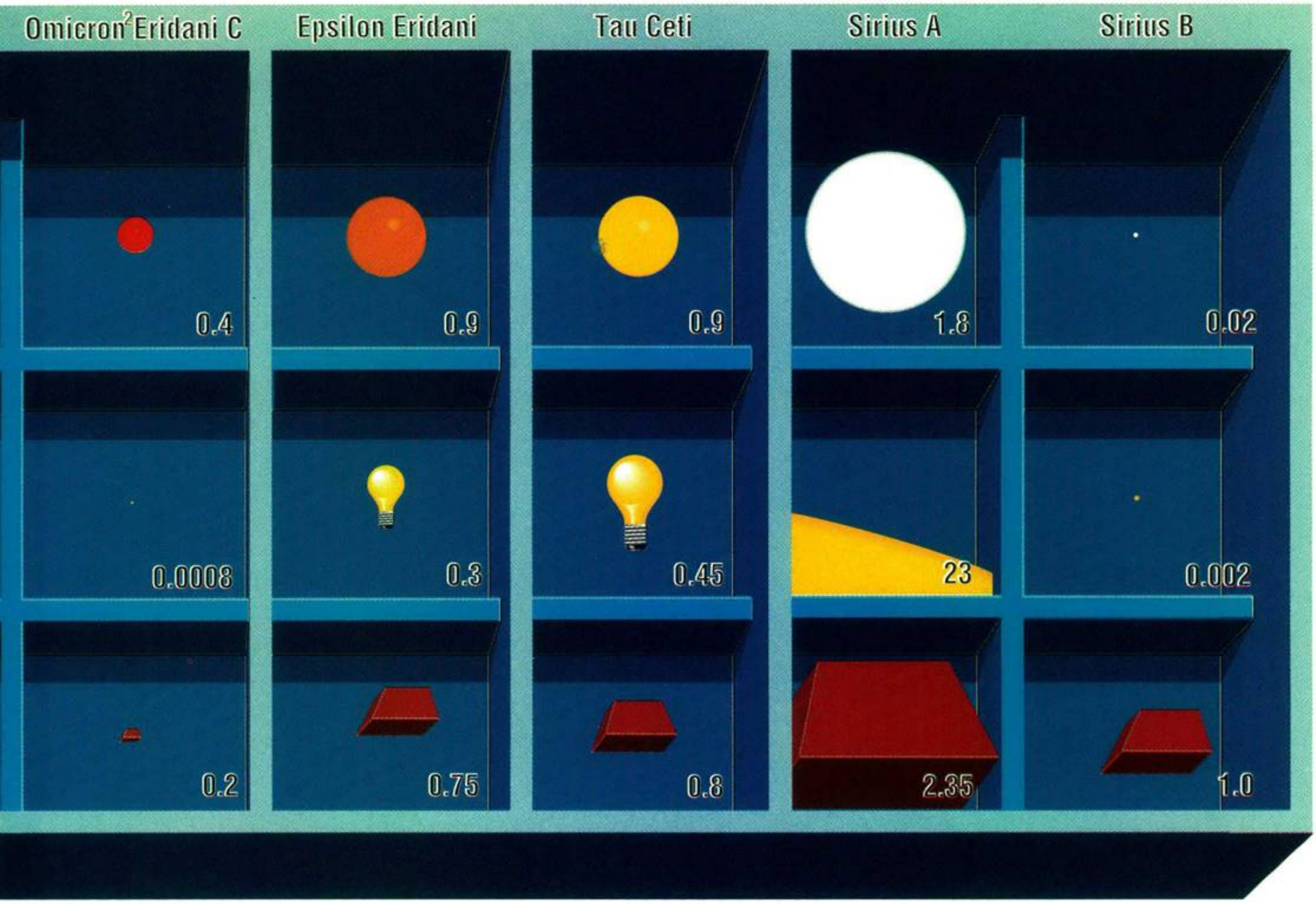

Procyon
11.4 light-years
Omicron² Eridani
16.0 light-years
Sun
Epsilon Eridani
10.8 light-years
Tau Ceti
11.7 light-years
Sirius
8.8 light-years



THE FALL FOOTBALL STARS are a diverse lot, containing the massive stars Sirius and Procyon and some suns — like Omicron^2 Eridani B and C — with fractions of the Sun's mass and luminosity. Diagrams by Thomas L. Hunt.

dim and so close to the primary that it is out of the reach of all but the very largest telescopes. Now swing your telescope over to Tau Ceti, a single star 11.8 light-years from Earth and, at spectral class G8, a near twin to our own Sun.

In a sweet coincidence, the most distant of our naked-eye stars in this neighborhood is also the most spectacular in the telescope. This is Omicron^2 Eridani, 16.3 light-years away. I consider it to be the finest triple star in the sky. The bright primary is a K-type star, almost a duplicate of Epsilon Eridani. Some 83" away from the primary star and close to each other (only 7.6" apart) are the other two stars in this system. What makes this object so beautiful is that the B component is a white dwarf and the C component, slightly dimmer, is a red dwarf. The color combination is hypnotizing, especially with the bright orangy primary shining nearby. The red star appears deeper and the white star brighter as the suns snuggle so close to each other, and the primary takes on a bit more of a yellowish cast when the eye shifts over to it. You find it difficult to tear your eyes away from this scene!

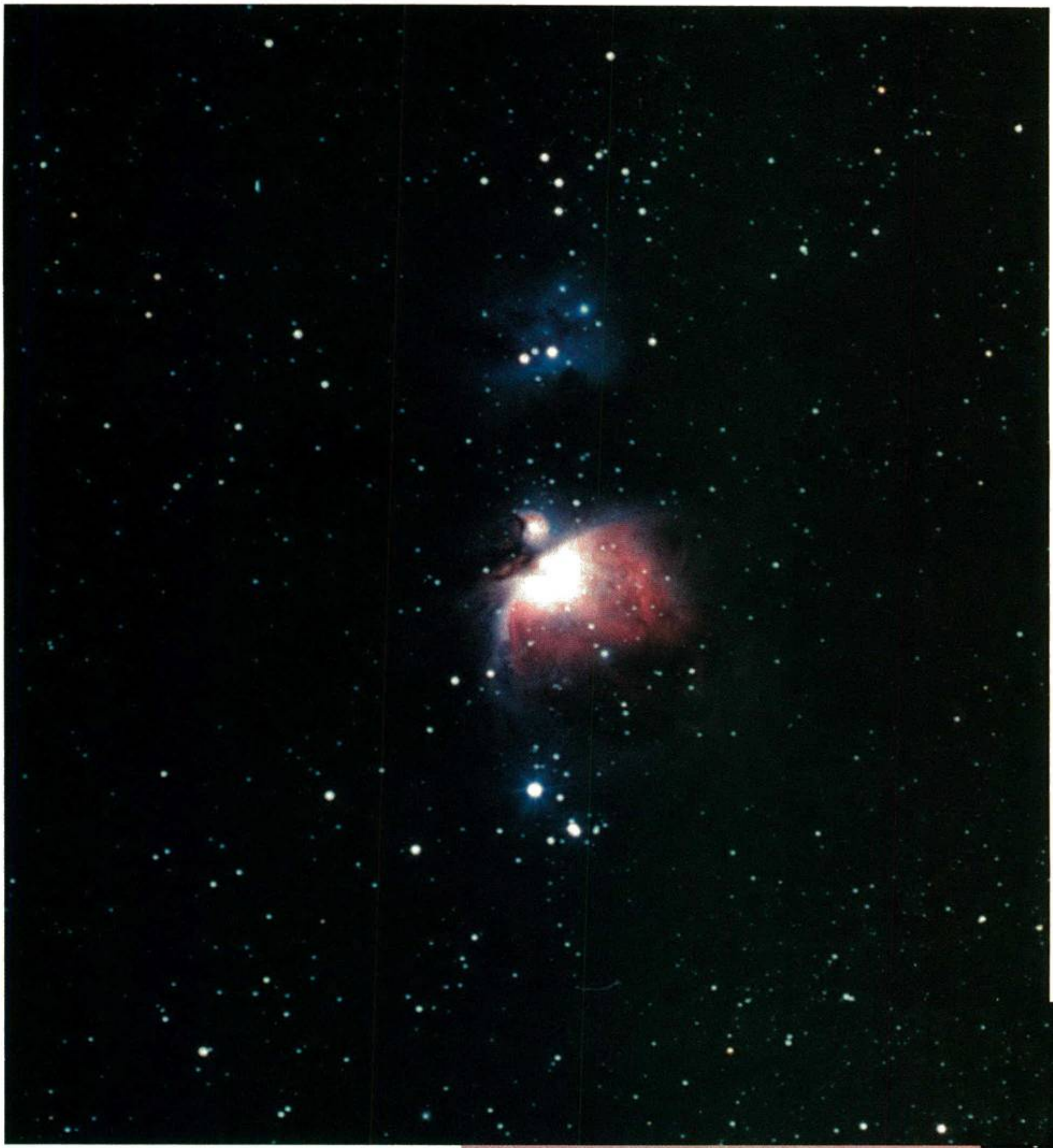
Instant Astronomy

Why should you care about observing these nearby bright stars? This observing project is easy to carry out, is available to even the smallest telescopes, and has the additional advantage of giving you a sense of the three-dimensional nature of space. We know that stars lie at different distances, and this project enables you to see a wide variety at greatly different distances. The depth of the scene hits hardest if you occasionally glance at Rigel, apparently right in the middle of these stars, but actually 900 light-years distant.

Someone is bound to call attention to the fact that I have been talking about the nearest naked-eye stars only, forgetting that there are many other nearby stars too dim to be seen without optical aid. Thus my original statement that five of the eight closest naked-eye stars are within 80° of each other doesn't seem to mean much. But consider this: nine of the 23 closest bright star systems are in this very part of the sky, barely 90° apart. To get this figure, I omit Omicron^2 Eridani (too far away) and add the five nearby telescopic star systems in this neighborhood (Luyten 726-8 in Cetus, Luyten 789-6 in Aquarius, Lacaille 9352 in Piscis Austrinus, BD +5° 1668 in Canis Minor, and Ross 614 in Monoceros).

Whether you concentrate on naked-eye stars or all the star systems near our own, many neighbors lie near the Fall Football. So the next time you see it, check out our nearest galactic neighbors. Perhaps on some distant planet a creature is missing an alien football game so it can stare right back toward you. ☐

John Mood is an experienced observer living in San Diego, California. His last article was "Logbook: Voyager 2 at Neptune" in the January 1990 issue.



SHARP AS A TACK, Ektar 25 lends itself to deep-sky photography with Schmidt cameras and fast telephoto lenses. The slow, fine-grained film has good sensitivity to both red and blue objects, as demonstrated in photos of the Orion Nebula region (above) and the Pleiades (right). Both are 10-minute exposures with an 8-inch f/1.5 Schmidt camera on hypered Ektar 25. Photos by Chris Schur.

Fieldtesting Kodak's Ektar Films

Kodak's Ektar print films provide the astrophotographer with a terrific trio of fine-grained color emulsions to use on targets ranging from the Moon to faint galaxies.

by Chris Schur and members of the Saguaro Astronomy Club

Films from Kodak used to fill the astrophotographer's camera bag. But in the last few years, amateur astronomers wanting to capture the sky in color have turned increasingly to fast, fine-grained films from companies such as Konica and Fuji. The tremendous speed of Konica 3200 print film has made it a favorite of astrophotographers looking to capture the faintest targets in the least amount of exposure time. And the superb color rendition of Fujicolor Super HG 400 has earned it the respect of deep-sky and planetary photographers. With new color films such as these appearing on the market every few months, old Kodak standards such as Kodacolor fell out of favor.

Then, at the beginning of 1989, Kodak introduced a new series of color print films called Ektar. The company brought out three versions: a slow, ultrasharp Ektar 25, a medium-speed Ektar 125, and a fast Ektar 1000. Would the new Ektars return Kodak to the lead in supplying color films for astrophotography? Members of the Saguaro Astronomy Club and I made it a group project to find out.

To evaluate the characteristics of the three films for long-exposure astrophotography, we used a 50mm f/1.4 lens on a 35mm camera mounted piggyback on a telescope. We used both off-the-shelf film samples and samples we "hypered" to test the response of the Ektars to gas-hypering. (Gas hypersensitization — hypering for short — is a treatment that prevents a film from losing sensitivity during long exposures. Hypering involves placing the film in a heated tank filled with a mixture of hydrogen and nitrogen gas for several hours.) Both normal and hypered versions were given the same tests and were developed together for comparable results in Bessler CN2 color negative chemistry at 100° Fahrenheit.

For most color films, the optimal hypering time occurs when the base density of unexposed frames looks slightly darker than the density of unhypered frames. Longer hypering times will result in prints that are discolored, while shorter times do not achieve maximum film speed.

Ektar 25 — Slow but Sharp

We found that for Ektar 25 the optimum hypering time occurred in 16 hours at 50° Celsius at 1 psi pressure. By comparing hypered versus unhypered negative strips, we determined that for moderate exposure times (about 10 minutes) hypering boosted Ektar 25's effective speed by a factor of 8. This is a very impressive speed gain for any film.

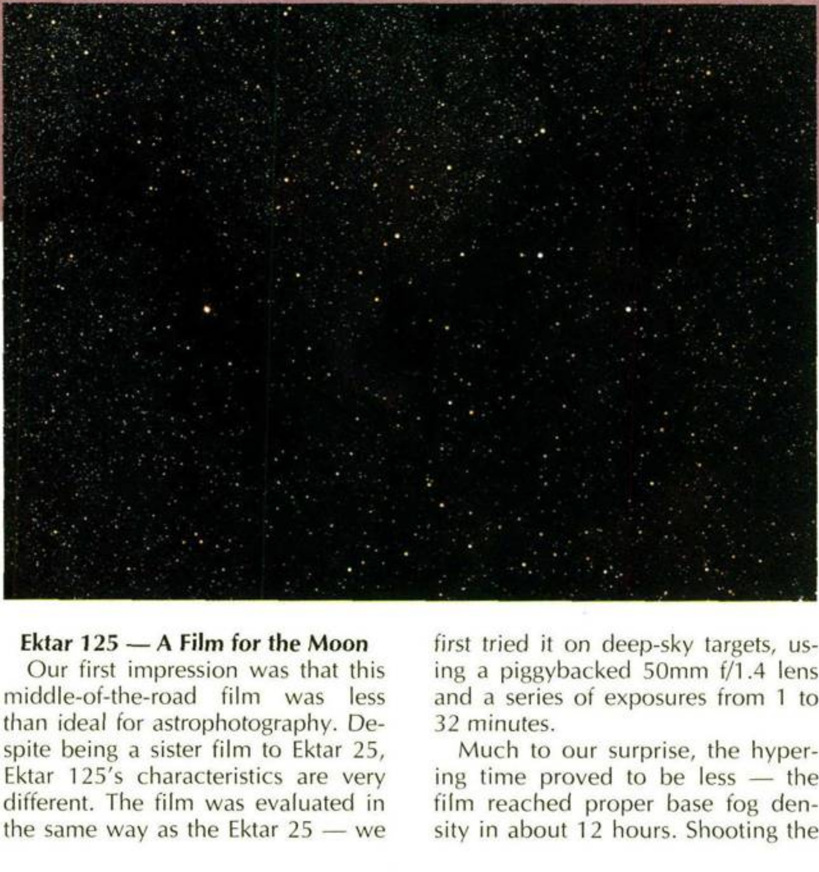
The best exposure with the 50mm f/1.4 lens on hypered Ektar 25 proved to be about 8 to 10 minutes. From the crisp star images and well-rendered emission nebulosities in Cassiopeia (our test objects), it became evident that Ektar 25 film has a much higher contrast and red sensitivity than the other Ektar emulsions. With a 10x magnifier the grain on the negatives was invisible. This immediately gave us high hopes for hypered Ektar 25 as *the* film for Schmidt and telephoto shots. Its fine grain should be a good match for the high-resolution but small image sizes typical of these optical systems.

To follow up on our suspicion, we loaded hypered Ektar 25 into a Celestron 8-inch f/1.5 Schmidt camera. We tried 8- to 10-minute exposures on a number of deep-sky objects that included samples of red emission nebulosities, blue reflection nebulae, and a selection of galaxies and star clusters. The resulting photos were superb. Ten-minute exposures yielded crisp, colorful images

Hypered 25 vs. Unhypered 125

WHEN HYPERED, Ektar 25 produces deep-sky photos comparable to or better than those produced by unhypered Ektar 125. However, Ektar 25 produces a much finer-grained image. The slower film also has better red sensitivity and contrast than Ektar 125. Photos on this page by Chris Schur.

HYPERED EKTAR 25: The North America Nebula, 10-minute exposure, 8-inch f/1.5 Schmidt camera.



UNHYPERED EKTAR 125: The North America Nebula, 8-minute exposure, 8-inch f/1.5 Schmidt camera.

with excellent contrast that brought out internal dark nebulae and dust lanes in all types of objects tested. *The film responds well to both red* and blue objects, crisply recording the red of the Pelican Nebula as well as the blue brush strokes of nebulosity in the Pleiades cluster.

To get equivalent results with slower telephoto lenses (we used a 135mm lens at f/2.8) required exposures in the range of 30 minutes or so. Since guiding half-hour exposures isn't too unmanageable, astrophotographers will be able to exploit the ultrahigh resolution of Ektar 25 for piggyback wide angle and telephoto lens shots. But only if the film is hypered. As you might expect, normal, untreated Ektar 25 proved to be far too slow for deep-sky photography.

Ektar 125 — A Film for the Moon

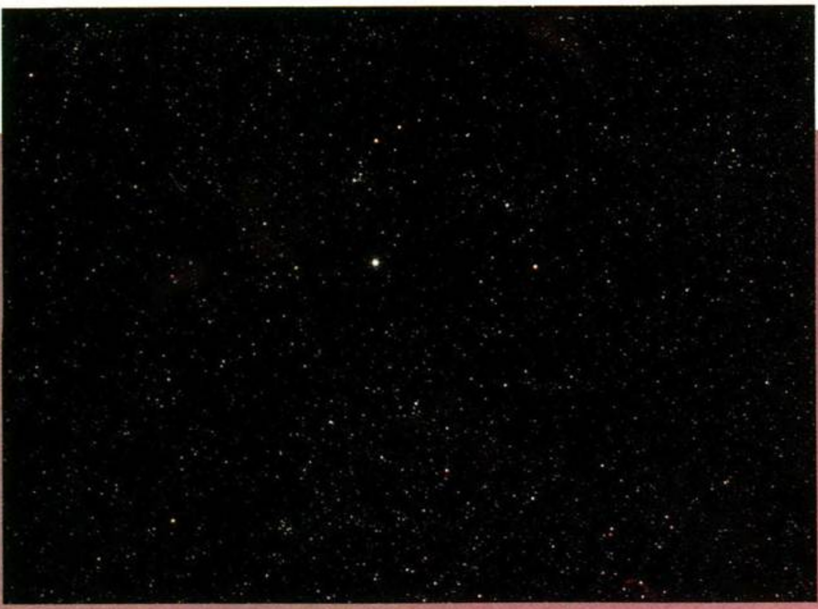
Our first impression was that this middle-of-the-road film was less than ideal for astrophotography. Despite being a sister film to Ektar 25, Ektar 125's characteristics are very different. The film was evaluated in the same way as the Ektar 25 — we first tried it on deep-sky targets, using a piggybacked 50mm f/1.4 lens and a series of exposures from 1 to 32 minutes.

Much to our surprise, the hypering time proved to be less — the film reached proper base fog density in about 12 hours. Shooting the

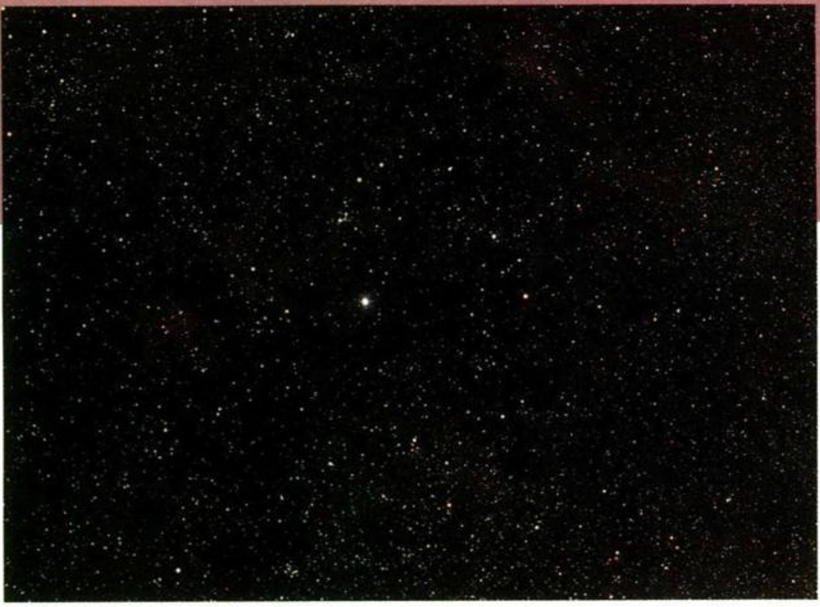
Recommended Deep-Sky Exposures

Focal Ratio	Ektar 25 Hypered	Ektar 125 Unhypered	Ektar 125 Hypered	Ektar 1000 Unhypered	Ektar 1000 Hypered
1.4	10	45	8	3	1.5
2.0	20	90	16	6	3
2.8	40	NR	32	12	6
4.0	80	NR	64	24	12

NOTE: All times are listed in minutes. We do not recommend deep-sky photography with unhypered Ektar 25 nor with unhypered Ektar 125 with f/ratios of f/2.8 or slower.



HYPERED EKTAR 25: The Gamma Cygni region, 10-minute exposure, 8-inch f/1.5 Schmidt camera.



UNHYPERED EKTAR 125: The Gamma Cygni region, 8-minute exposure, 8-inch f/1.5 Schmidt camera.

same Cassiopeia star field, we found that hypered Ektar 125 produced the best results with an 8-minute exposure. Since this optimum exposure time was similar to what we found for hypered Ektar 25, this means that hypering the 125 emulsion produced a less significant speed gain than it did with Ektar 25 film. Even though Ektar 125 is technically 5 times faster than Ektar 25, the faster film did not maintain its speed advantage over the slower emulsion in long exposures when hypered. On top of this, we noticed that Ektar 125's contrast and red sensitivity were very low — test shots revealed only a trace of the emission nebulosity that showed up so well in the Ektar 25 test shots.

To be consistent we tested using a Schmidt camera and telephoto lens, though we didn't anticipate great results. As with Ektar 25 we used 8-minute exposures for the Schmidt camera photos and 30-minute exposures for the shots with the 135mm f/2.8 telephoto.

As we expected, the North America Nebula looked pale and tepid, and the nebulosity in the Pleiades was nearly nonexistent. However, in shots of the Orion Nebula (M42) and the Andromeda Galaxy (M31), the bright cores of these objects were not burned out as they were in Ektar 25 shots. The photos of these bright targets were actually quite pleasing, a result probably due to the low contrast that seems to be characteristic of this film.

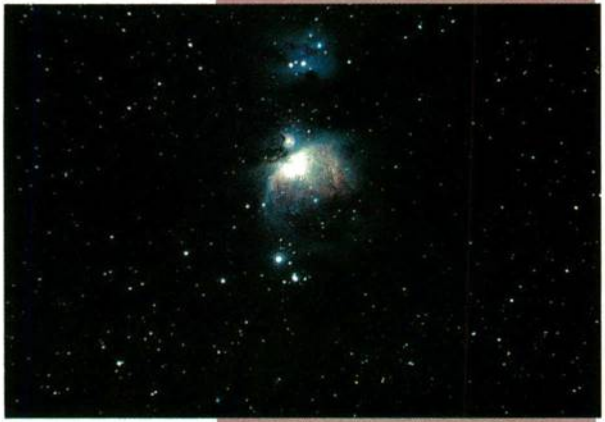
The low contrast of Ektar 125 suggested that it might be a suitable film for lunar photography, a target with extreme contrasts between light and dark. Films with normal or high contrast have a tough time recording details in anything but a narrow region of brightness along the lunar terminator. With this in mind, a number of us tried prime focus and projection lunar photography. The results were excellent. The low contrast and wide exposure latitude did indeed increase the detail visible on the terminator, without our having to overexpose and sacrifice detail on the rest of the lunar disk.

In addition, we found that Ektar 125's fine grain compares very favorably with the extremely fine grained black and white 2415 emulsion, which is the mainstay of many lunar photographers. Ektar's neutral color characteristics yielded pleasing creamy-white lunar images, with an unwanted greenish tint showing up only on underexposed images.

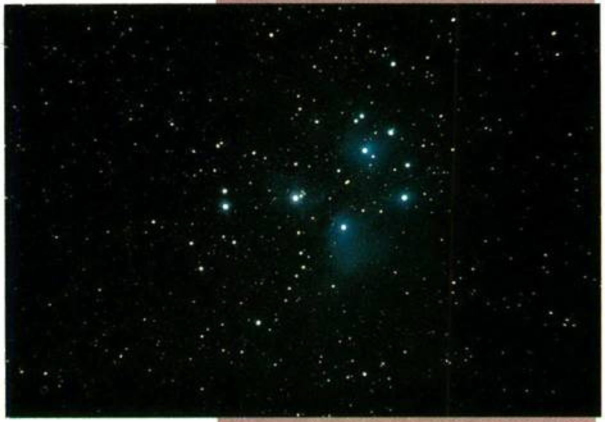
Ektar 1000 — A Deep-Sky Winner

High film speed generally means large grain size and poorly resolved images. We found that Kodak has made great strides in film technology since the days of VR1000. The grain size and structure of Ektar 1000 are much better than they were in Kodak's previous high speed films. This in turn leads to better detail and resolution in the final

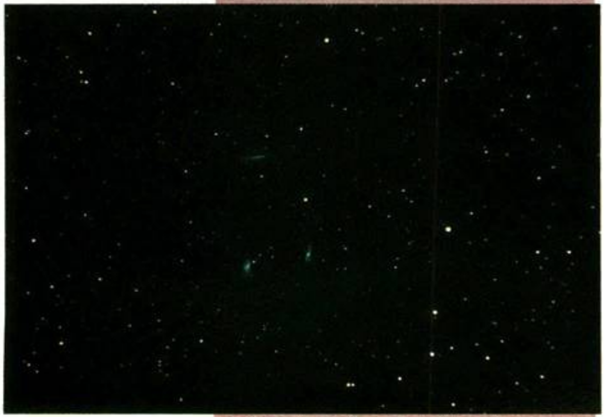
Unhypered 1000



THE ORION NEBULA shows some subtle pinks and strong blues in this 15-minute exposure on straight-out-of-the-box Ektar 1000.

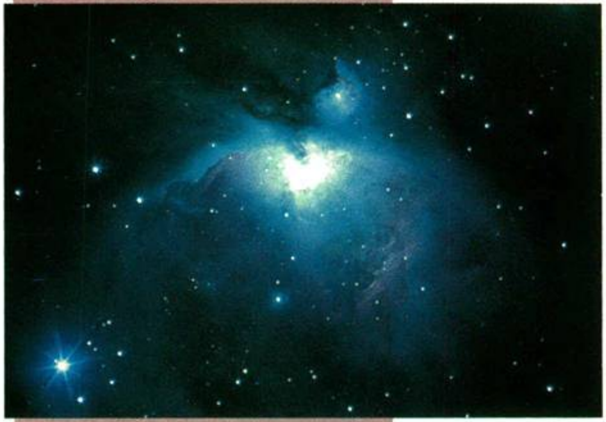


THE PLEIADES CLUSTER and its wispy reflection nebulosity show up well on Ektar 1000 because of the film's excellent blue sensitivity.

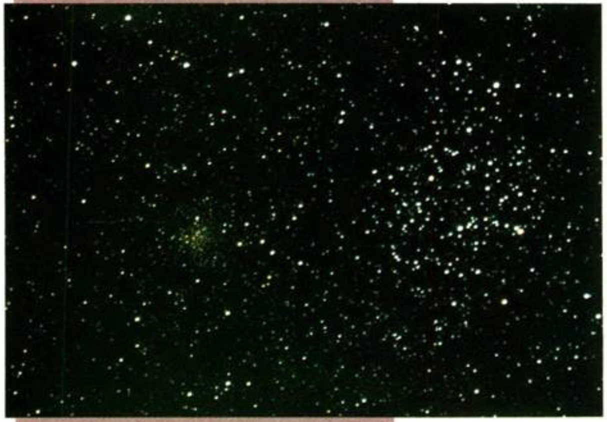


M65 AND M66 are good targets for Ektar's high speed. All photos in this column of unhypered photos are 15-minute exposures with a 6-inch f/3.6 Schmidt Newtonian.

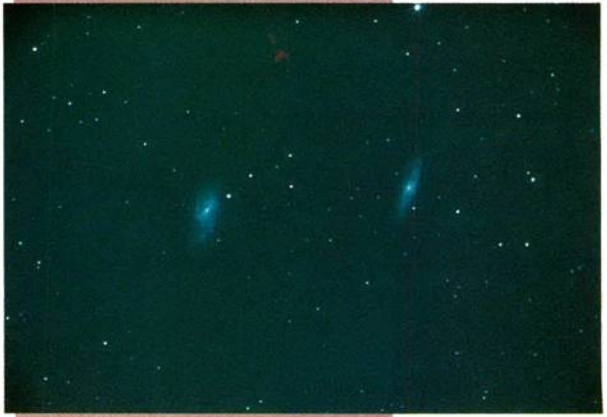
Hypered 1000



THE ORION NEBULA CLOSE UP on Ektar 1000 shows how the film shifts even further to the blue when it is gas hypered for extra speed.



M35 AND NGC 2158 and other open and globular star clusters are suitable targets for Ektar 1000, either hypered or unhypered.

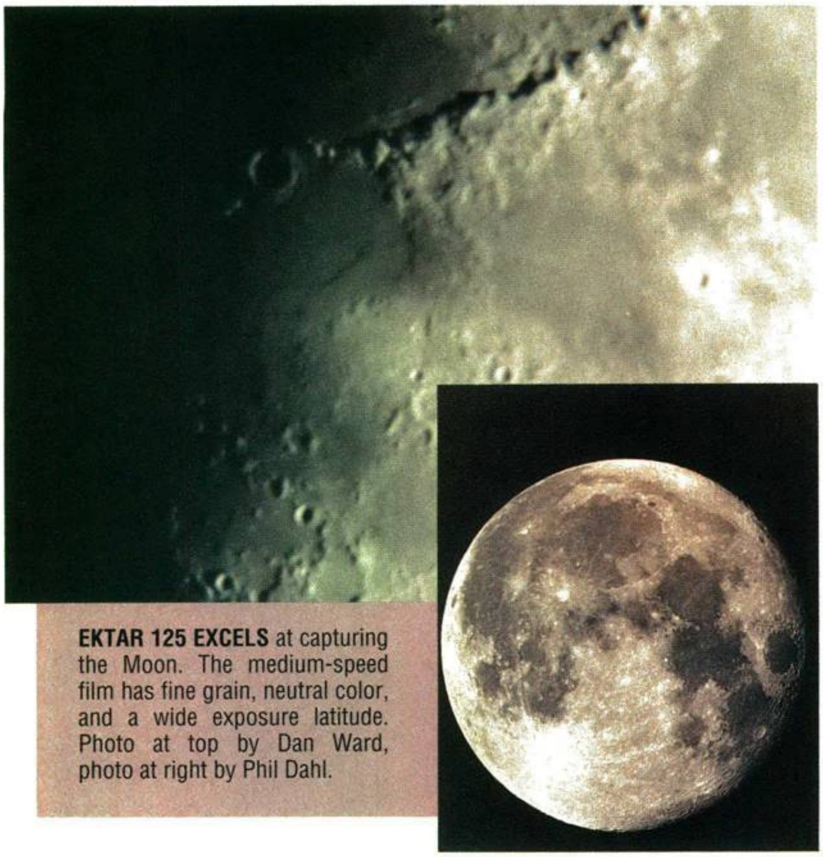


M65 AND M66 exhibit fine detail on hypered Ektar 1000. Photos in this column are 20-minute exposures with a 14-inch f/5 Newtonian. All photos on this page by Chris Schur.

Suggested Hypering Times

Film	Time (hours)	Temp (°C)	Pressure	Approx. Speed Gain
Ektar 25	16	50°	1 psi	8x
Ektar 125	12	50°	1 psi	6x
Ektar 1000	10	50°	1 psi	2x

NOTE: Ektar films respond very well to hypering, using the standard mixture of 92% nitrogen and 8% hydrogen. We used a Lumicon Model 300 hyper kit. With similar setups you can use the above numbers as starting points. However, we found that with Ektar 1000, hypering introduced a bluish cast into the background color and added little to its recording power.



EKTAR 125 EXCELS at capturing the Moon. The medium-speed film has fine grain, neutral color, and a wide exposure latitude. Photo at top by Dan Ward, photo at right by Phil Dahl.

print. Of the three films, this is certainly the film of choice for deep-sky photos at the prime focus of a telescope.

However, we did find that the color sensitivity of this emulsion is unusual. Although Ektar 1000 has only moderate red sensitivity, it has among the highest sensitivities in the blue end of the spectrum of any film we have tried.

In our initial testing with this film, we used a 14-inch f/5 Newtonian with a variety of exposures on the Orion Nebula, the reflection nebulosity NGC 1973-5-7 just to the north, the star cluster M41 in Canis Major, and the pair of galaxies M65 and M66 in Leo.

The film's unusual color sensitivity was first evident in the Orion Nebula shots. The nebula turned out blue with a lavender ring of nebulosity surrounding the outer core. However, the high blue sensitivity of Ektar 1000 also brought out a tremendous amount of detail and nebulosity in NGC 1973-5-7. This reflection nebula photographed as a beautiful sky-blue color studded with brilliant white stellar gems throughout. The good contrast of this film also revealed internal details such as dark nebulae and rifts.

The performance on open clusters such as M41 was stunning. The fast Ektar recorded hundreds of stars, each retaining its own subtle color and brightness, all in exposure times under 20 minutes. The relatively fine grain of this emulsion (for an ISO 1000 speed film) makes it suitable for well-resolved shots of globular clusters and rich open clusters.

We found that the subtle features of galaxies also record very well with Ektar 1000. M66 showed delicate internal details such as knots and dark lanes in its spiral arms, while its neighbor galaxy M65 clearly revealed its sharp stellar core and dark equatorial dust ridge. Recording such details in mere 20-minute exposures, especially with unhypered film, makes Ektar 1000 a real winner for capturing galaxies, reflection nebulae, and globular and open clusters. In fact, we found that hypering contributed little to this film's already high sensitivity.

A Film for Every Occasion

From our tests of the Ektar trio in a variety of applications, we can say that the Ektar series of films will have a substantial impact on amateur astrophotography. Ektar 25 is ideal for Schmidt cameras and fast telephoto lenses. But for deep-sky subjects it needs to be gas-hypered.

On the other hand, Ektar 125's inherently low contrast did not suit it for deep-sky photography. But its low contrast, fine grain, and neutral color balance make it great for lunar photography.

Finally, we found that Ektar 1000 has surprisingly fine grain for such a high-speed film and has moderate red sensitivity but very good blue sensitivity. Even when unhypered, the speed of this film made it possible to use comfortably short exposures. Ektar 1000 is also a superb film for constellation shots with a fixed camera on a tripod, making this a film we can recommend highly for astrophotography novices.

At the end of our tests we were left quite impressed with Kodak's Ektar films. Whether they will replace competitors' film brands in astrophotographers' gadget bags remains to be seen. Nevertheless, no matter what type of astrophotography you're doing, we found that there is an Ektar film just right for your needs. □

Chris Schur is an avid astrophotographer living in Payson, Arizona. In preparing this review he was assisted by members of the Saguaro Astronomy Club of Phoenix.

Observing Bright Planetary Nebulae

All it takes is a small telescope to observe the brightest planetary nebulae — glowing shells of gas cast off by dying stars.

by Alan Goldstein

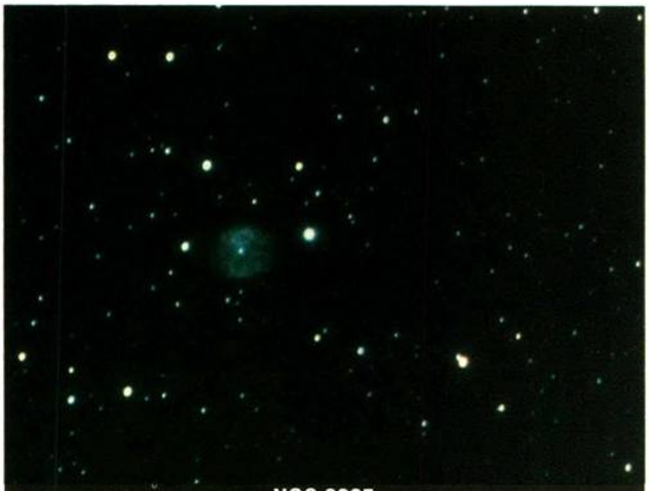
The universe is an awfully strange place. In it, matter is neither created nor destroyed but rather is continuously recycled by the deaths of old stars and births of new ones. A look at the lifestyles of stars — not of the rich and famous but of the hot and distant — reveals several ways in which the same material gets used over and over again.

Stars die in many ways, from cooling slowly like burning embers to violently exploding as supernovae. Somewhere in the middle lies the class of stars — including our Sun — that will calmly puff off shells of gas, forming what astronomers call planetary nebulae.

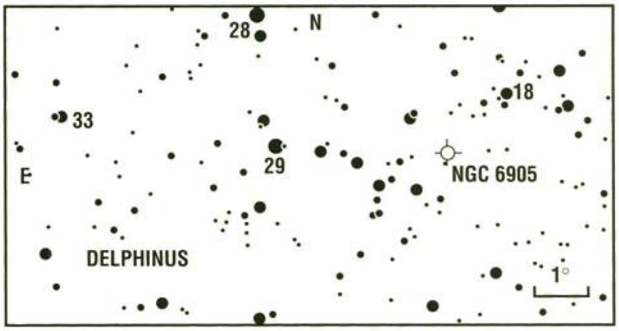
Observing these nebulae is a joy because many of them are bright and colorful, appearing as gray-green or blue-green disks. The challenge is not so much to find a planetary nebula, but to see the central star — the originator of the thin, luminescent gas cloud. The range of planetary nebulae runs from easy planetaries with faint central stars to faint nebular disks with bright central stars.

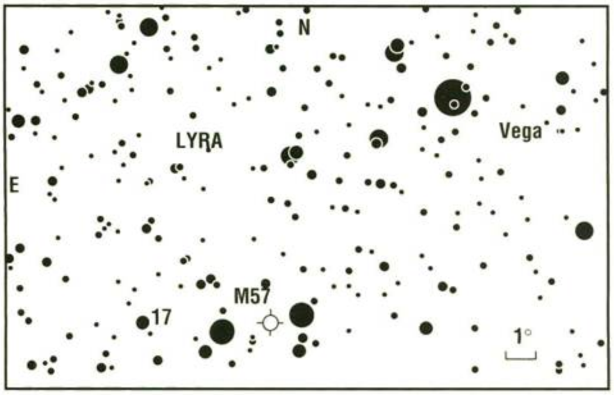
The prettiest planetary nebula in the sky also has a challenging central star. The **Ring Nebula** (M57, NGC 6720) in Lyra is easy to locate, lying between the bright stars Beta and Gamma Lyrae. In small telescopes, the Ring appears as a gray-green puff of smoke shaped like a ring. Larger scopes reveal a strong greenish color due to the presence of doubly ionized oxygen in the nebulosity. The perceived intensity varies from person to person and with differing telescope size. This nebula is a favorite of everybody. Beginners like it because it is easy to find and view, while most experienced observers never get tired of scrutinizing it to try to glimpse the central star.

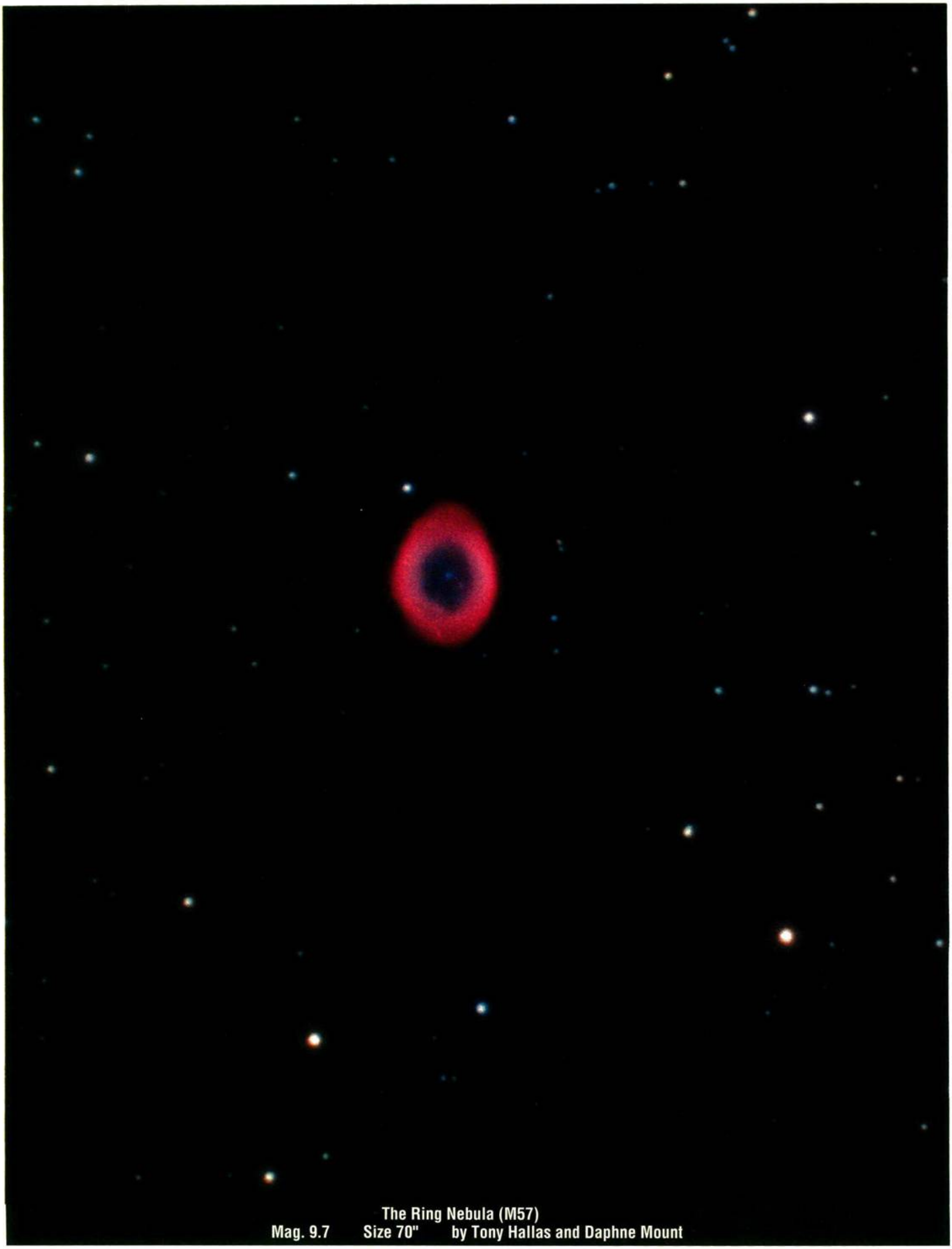
M57's central star glows dimly at about magnitude 14.8. Theoretically, this places it within the range of a 12.5-inch telescope under ideal skies. Yet few observers have seen it in a telescope of that aperture. I have observed the Ring Nebula many times with a 21-inch telescope. On many nights the Ring's central star is invisible with this telescope. On the other hand, some keen-eyed observers claim to have seen the central star with a 5-inch telescope. Why such a discrepancy? There's no straight answer. It's due to a combination of factors, including experience, optics, transparency, the individual's sensitivity to blue light, and possibly the star itself. Because of the wide range of telescopes in which this star has been seen (and not seen), some astronomers believe it is a variable star.



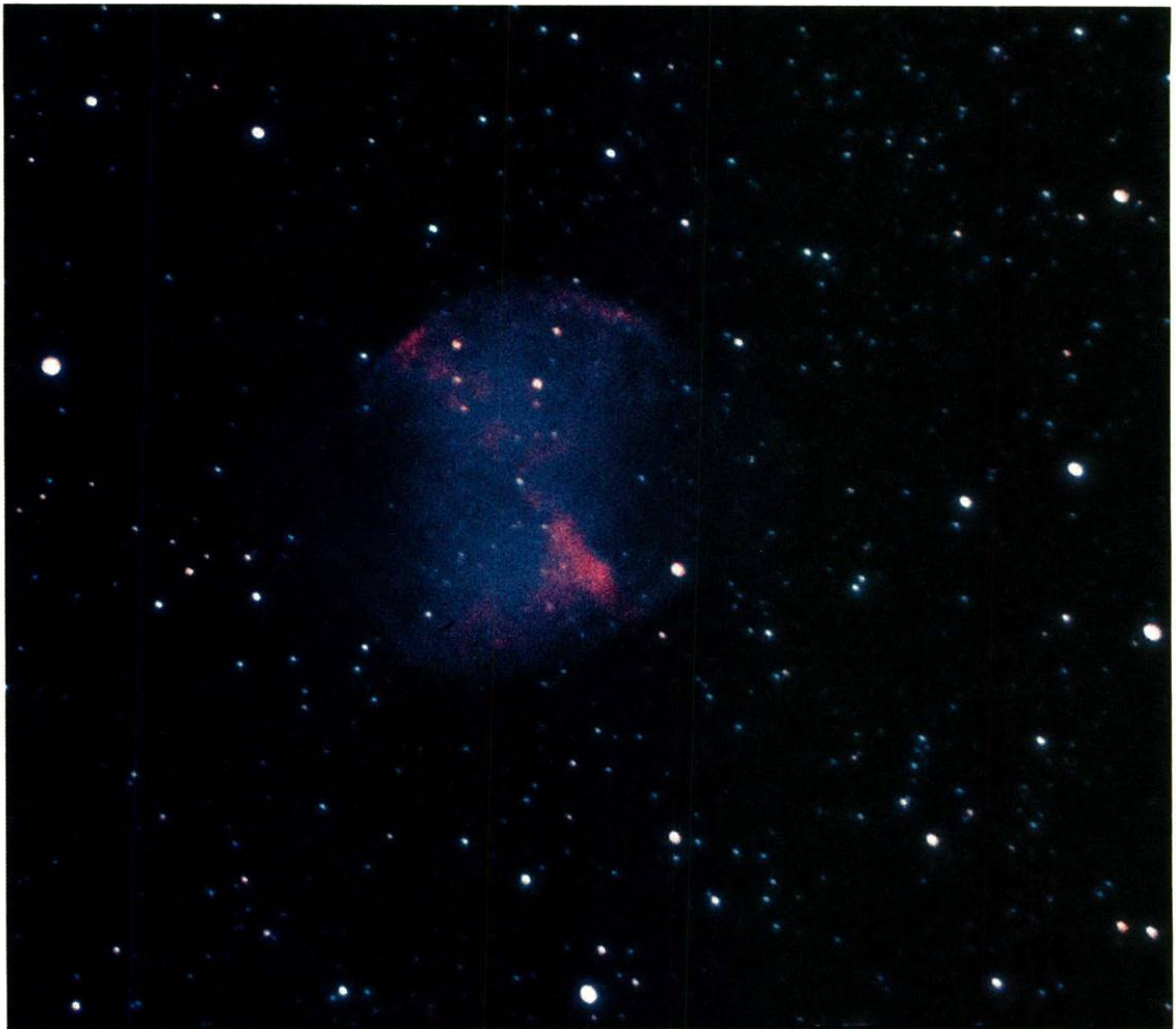
NGC 6905
Mag. 11.9 Size 46" by Jack B. Marling



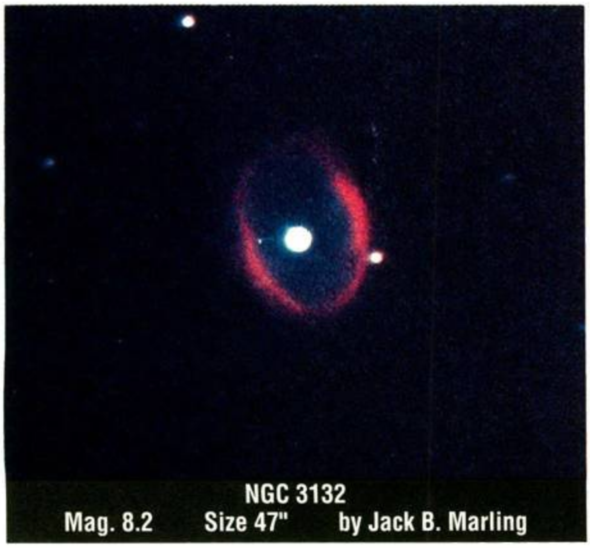




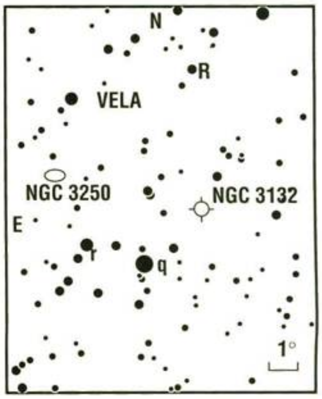
The Ring Nebula (M57)
Mag. 9.7 Size 70" by Tony Hallas and Daphne Mount



The Dumbbell Nebula (M27)
Mag. 7.6 Size 350" by Kim Zussman



NGC 3132
Mag. 8.2 Size 47" by Jack B. Marling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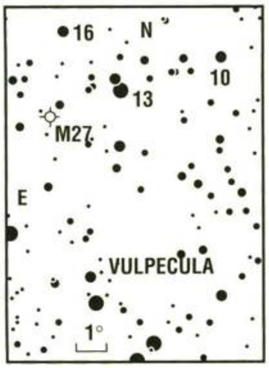
16
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1°

In addition to M57, we'll look at ten of the finest planetaries visible in the autumn sky. For convenience, we'll split them into three groups — one visible in the evening, another after midnight, and a third in the early morning sky.

The Evening Planetaries

The **Dumbbell Nebula** (M27, NGC 6853) in Vulpecula is a larger, brighter planetary than the Ring. The fact that M27 glows at magnitude 7.6 and measures 350" across puts it within easy reach of finderscopes and low-power binoculars. At about 50x, the oval disk appears to be evenly illuminated. With small telescopes, the notches in the dumbbell become easy. With larger instruments, the nebula takes on a mottled, patchy appearance. The distribution of the gas in the shell forming the Dumbbell Nebula is obviously not uniform in nature, but contains clumps of hot gas, hence the mottled appearance.

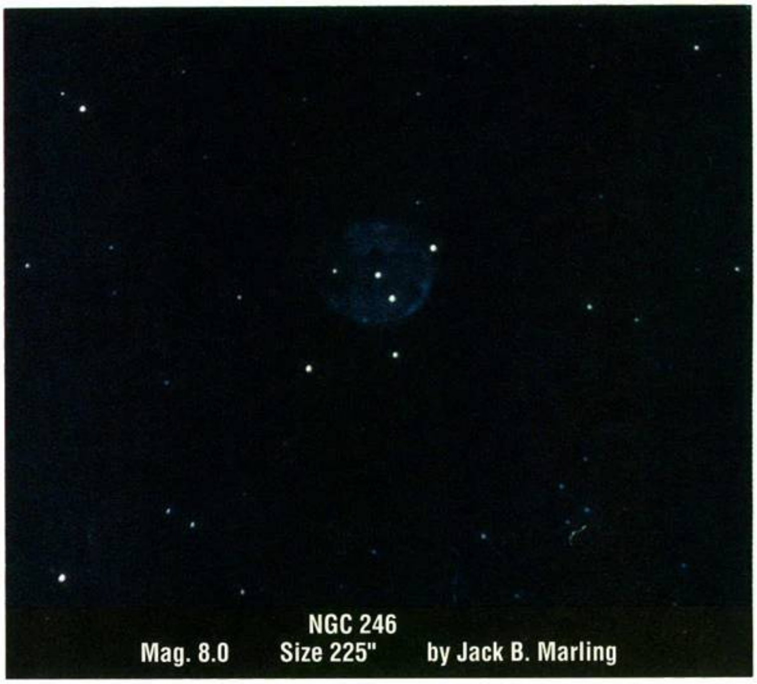
About half of the nebula has a sharp, distinct edge, or shock front. Superimposed on the nebular "disk" are numerous foreground stars. In the center lies the magnitude 13.9 bluish star that formed M27. This star is not too difficult in an 8-inch telescope under good skies and has been picked up with a 6-inch under superb atmospheric conditions.

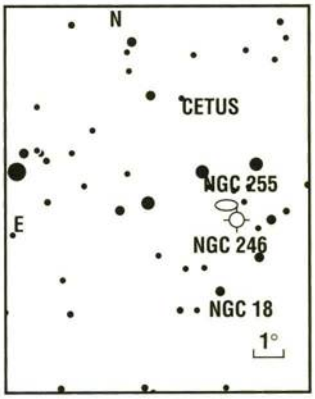
Much smaller than either M57 or M27, **NGC 6210** is nonetheless the finest planetary nebula in Hercules. In most telescopes, NGC 6210 appears as a blue-green disk glowing at magnitude 9.3 with a central star about three magnitudes fainter. This planetary is almost a magnitude fainter than M57, yet its central star is much brighter. The planetary's size is tiny, however: with a diameter of 14", NGC 6210 would fill only the central hole in the Ring Nebula. Large backyard scopes reveal some detail around the perimeter of this nebula's disk. The central star is visible in all but the smallest telescopes. With small scopes it can be resolved from the glow of the nebula with high magnification.

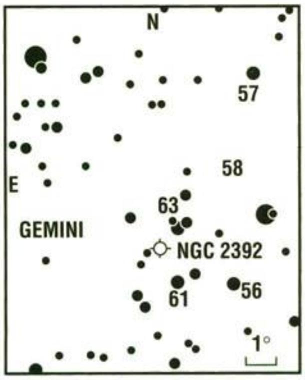
NGC 6905 is a fairly bright planetary nebula in Delphinus that is slightly fainter than NGC 6210. NGC 6905 has a magnitude of 11.9 and a 14th-magnitude central star embedded in its mottled disk. A 10-inch scope may be necessary to pick out this faint blue star. If you can see the central star in M27 without difficulty, turn your telescope to NGC 6905 — averted vision may help, but it frequently brightens the nebula more than the central star.

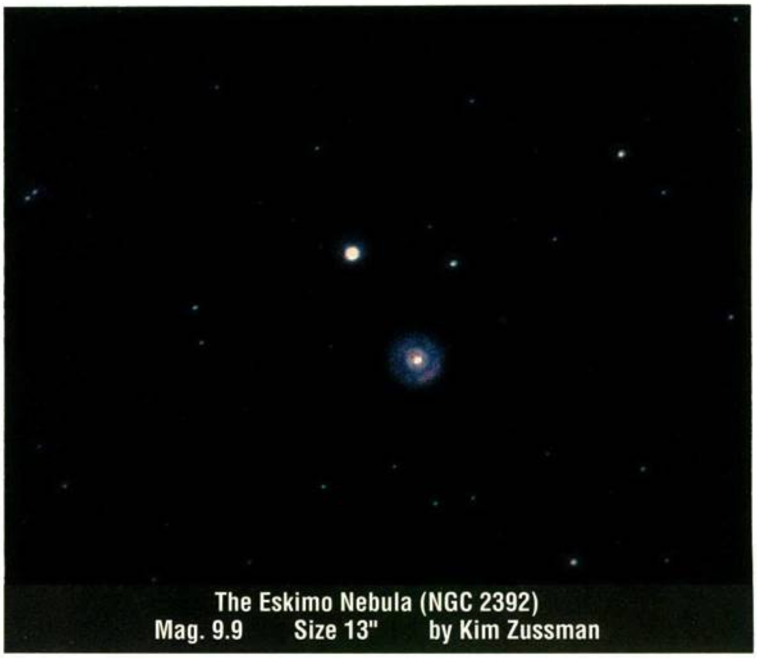
Moving into the Night

As the stars wheel westward, and midnight has come and gone, it's time to try spotting **NGC 7662**, the brightest planetary nebula in Andromeda. It is a roundish object 20" in extent. Glowing green, NGC 7662 is a spectacular late-year object. It presents another great disparity. Glowing brightly at 9.2 magnitude, the nebula is easily visible in binoculars or small scopes, but the challenging central star glows feebly at magnitude 13.2. In theory, a good 8-inch or 10-inch telescope will show this star. However, it is especially difficult to see because it is involved with the nebulosity. I have never observed this central star. A filter that transmits blue light may be capable of dimming the nebular glow sufficiently to show the star. Good luck with this one!


NGC 246
Mag. 8.0 Size 225" by Jack B. Marling

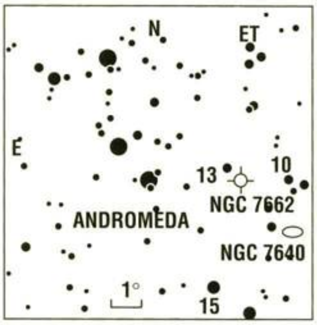





The Eskimo Nebula (NGC 2392)
Mag. 9.9 Size 13" by Kim Zussman

NGC 6210
Mag. 9.3 Size 14" by Jack Newton

NGC 4361
Mag. 10.3 Size 45" by Jack Newton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NGC 7662
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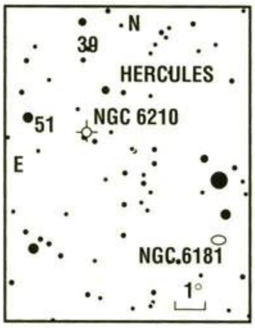
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NGC 6210
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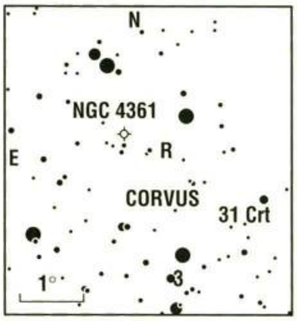
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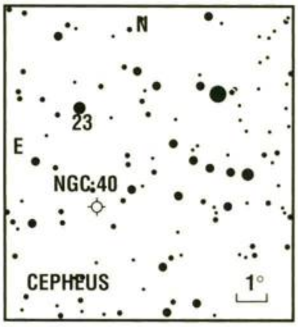
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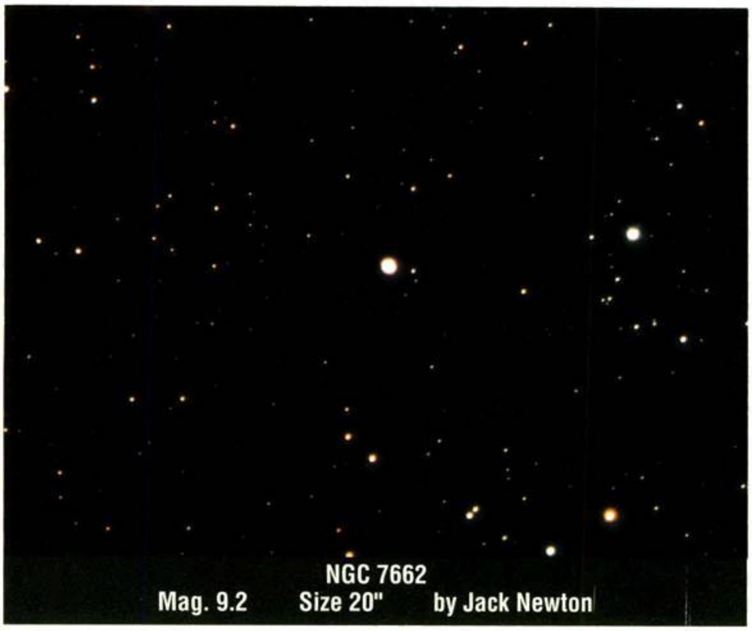
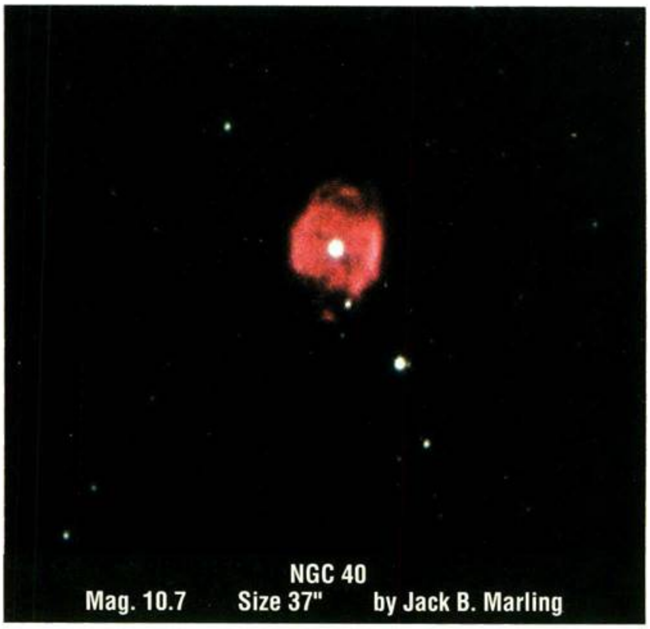


NGC 7662
Mag. 9.2 Size 20" by Jack Newton



NGC 40
Mag. 10.7 Size 37" by Jack B. Marling

NGC 40 is one of the brightest planetary nebulae in Cepheus. It is comparable to NGC 6905, glowing at magnitude 10.7. Its central star is similar to the one in NGC 6210, as it glows at magnitude 11.6. Both the nebula and the star are visible in small telescopes. The planetary is 37" across. Photographs show a somewhat squared-off ring with ansae (tenuously connected filaments or blobs of gas) along the long axis. The lower surface brightness of this nebula makes detail difficult to glimpse. The central star is not difficult with any telescope larger than 4 inches in aperture — a 3-inch telescope can detect the star under dark, transparent skies.

Visible in the southeastern sky after midnight, Cetus' **NGC 246** has a very low surface brightness. The central star is bright and conspicuous in small telescopes. The nebula's published magnitude of 8.0 is deceiving because this ghostlike object is definitely not

Bright Summer Planetaries

Object	R.A (2000.0)	Dec.	Mag.	Mag.*	Size	Con
NGC 40	0h13.0m	+72°32'	10.7	11.6	37"	Cep
NGC 246	0h47.0m	-11°53'	8.0	11.9	225"	Cet
NGC 2392	7h29.2m	+20°55'	9.9	10.5	13"	Gem
NGC 3132	10h07.7m	-40°26'	8.2	10.1	47"	Vel
NGC 3242	10h24.8m	-18°38'	8.6	12.0	16"	Hya
NGC 4361	12h24.5m	-18°48'	10.3	13.2	45"	Crv
NGC 6210	16h44.5m	+23°49'	9.3	12.9	14"	Her
M57	18h53.6m	+33°02'	9.7	14.8v?	70"	Lyr
M27	19h59.6m	+22°43'	7.6	13.9	350"	Vul
NGC 6905	20h22.4m	+20°07'	11.9	13.5B	46"	Del
NGC 7662	23h25.9m	+42°33'	9.2	13.2v?	20"	And

Object: Designation in Messier or NGC catalog. **R.A. and Dec.:** Coordinates in equinox 2000.0. **Mag.:** Photographic magnitude. Mag.*: V magnitude of central star; subscript B denotes blue magnitude. **Size:** Diameter in arcseconds. **Con.:** Constellation in which object lies.

easy in small telescopes. Even an 8-inch telescope requires good, dark skies to show NGC 246. The Ring Nebula, listed at nearly a full magnitude fainter, can be picked out under suburban sky glow, but M57 has a much higher surface brightness. At magnitude 11.9, the central star in NGC 246 is one of the brightest in the sky. A large instrument will reveal other stars superimposed on the somewhat annular gas shell. M27's disk is studded with stars, yet NGC 246 lies far from the Milky Way. Like the Dumbbell Nebula, this object contains irregular patches of bright gas. The unusual outline of the nebula may make the central star appear less "central" than it really is. What do you see in your telescope?

Before the Dawn

As the night continues, the bright constellations of winter will rise up over the eastern horizon. In this star-studded patch of sky you'll find another batch of bright planetaries. **NGC 2392** in Gemini is called the Eskimo Nebula because in long-exposure photos it resembles a face peering out from a fur-lined hood. Visually it is less graphic, appearing like a disk with a faint, outer rim. In large telescopes NGC 2392 looks like a double ring. The nebula itself has a visual magnitude of 9.9, the central star glows at magnitude 10.5. High magnification is necessary to distinguish the central star from the nebula. As is typical of high-contrast planetary nebulae, this object appears beautifully blue when viewed with large scopes.

NGC 3132 is a southern planetary in Vela just over the Vela/Antlia border. Nicknamed the Eight-Burst nebula, this object is a bright annular nebula similar to the Ring Nebula. At magnitude 8.2, NGC 3132 is easy to see in small telescopes. NGC 3132's southerly declination of –40° makes observing the planetary challenging for northern observers — look for it when it's near the meridian. At first glance, this object appears to have a bright central star. However, astronomers have found that the bright star appearing near the center of this object is not the progenitor star.

Located in Hydra is the bright, disklike planetary **NGC 3242.** This fine object has been called the Ghost of Jupiter because its oval shape and 16" dimension remind observers of the solar system's largest planet. Most observers see NGC 3242 as greenish-blue or blue, more typical of Uranus or Neptune rather than Jupiter. The oval shape appears ringlike in large telescopes. The central star is a reasonably bright magnitude 12.0, putting it within reach of all but the smallest telescopes.

The Ghost of Jupiter (NGC 3242)
Mag. 8.6 Size 16" by Joe Liddell

Our last planetary nebula is **NGC 4361** in Corvus. The diameter is a circular 45", somewhat smaller than the Ring Nebula. Very little detail is visible across the disk of NGC 4361 with either small or large telescopes. With instruments in the 4-inch to 6-inch range, it's best to look at NGC 4361 under very dark skies. The nebula's low contrast makes it extremely difficult in light-polluted skies. The central star should be detectable in a 4-inch scope under ideal conditions. An 8-inch instrument is necessary to see it with ease. The central star does not get lost in the glow of the nebula — as is the case with M57 and NGC 7662 — because of the very tenuous nature of the gas shell surrounding the central star.

This autumn try catching some planetary nebulae. Whether you're alone or at a star party, equipped with big telescopes or small, you can easily find planetaries and see nice detail within them. The opportunity to compare such objects as NGC 40 or NGC 3242 in a 3-inch, 8-inch and 16-inch telescope at the same time is extremely eye-opening. Whether you observe these planetaries with a small scope or a large one, you'll be sure to rate them high on your list of favorites in the autumn and winter skies. □

Alan Goldstein is founder of the National Deep Sky Observers Society, a nonprofit group dedicated to publishing information for backyard astronomers.

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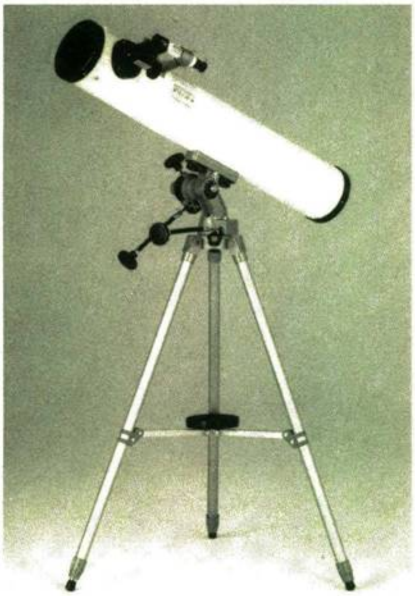

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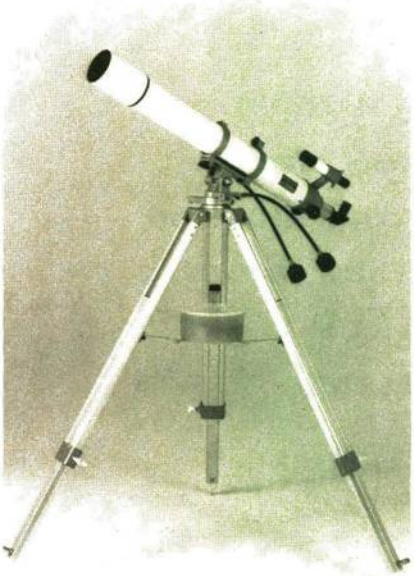
  - 18mm (50x)
  - 8mm (112x)
- 6x24 Finderscope
- Adjustable Aluminum Tripod



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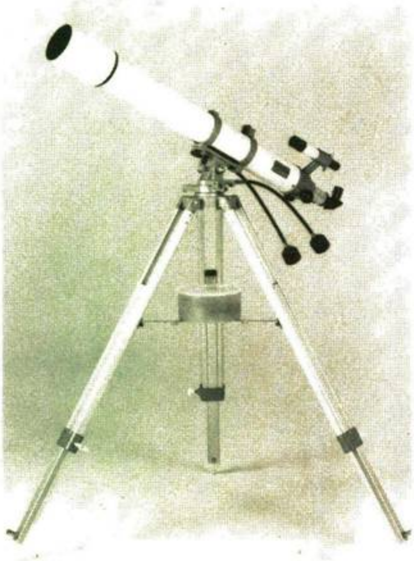

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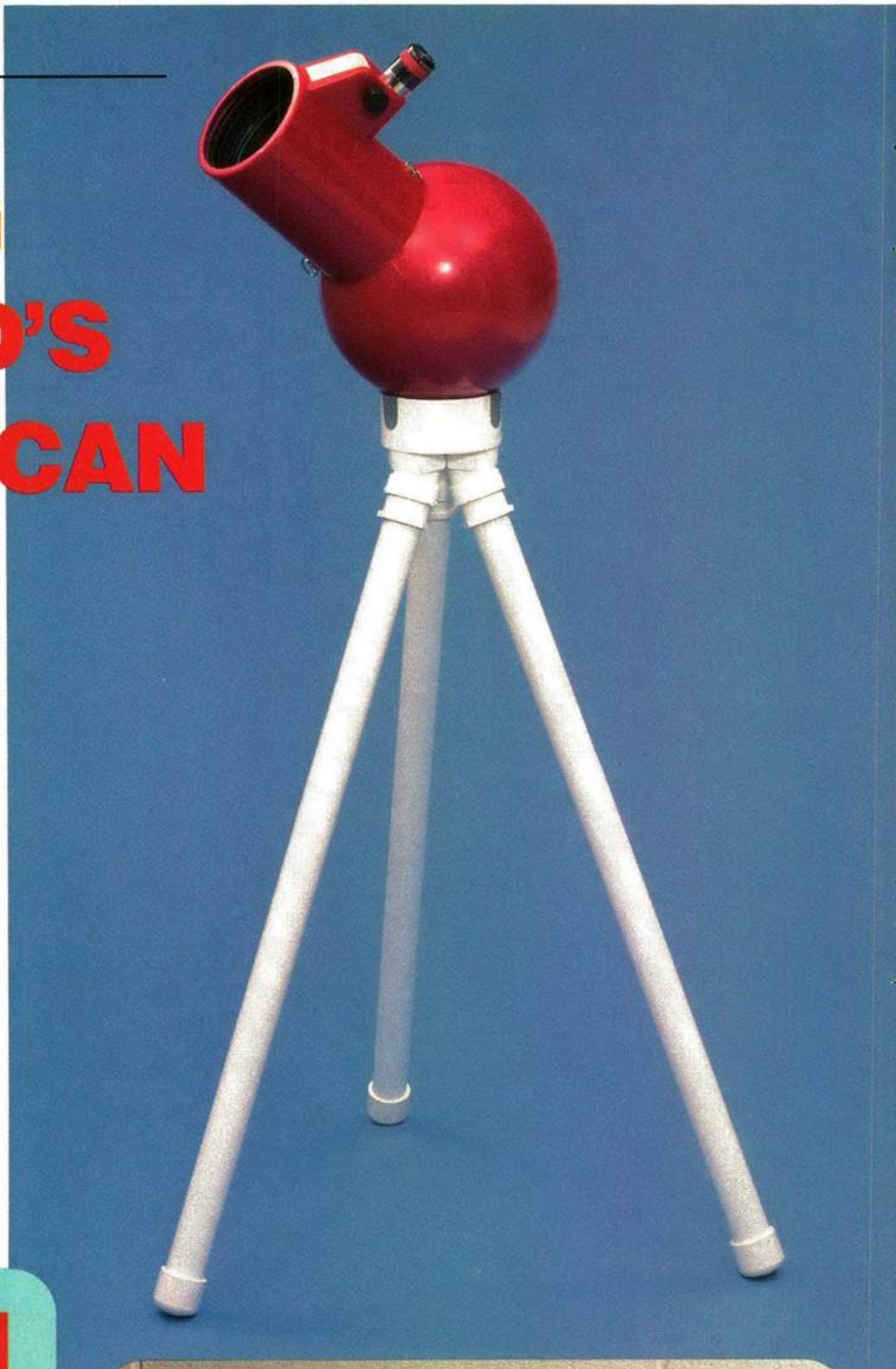
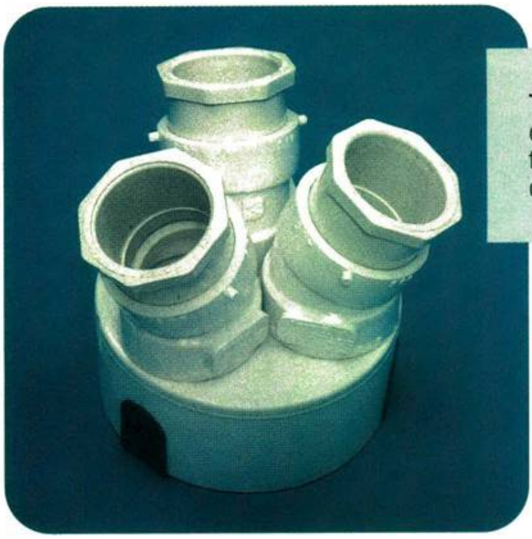


Here's a cheap and easy way to raise your Edmund Astroscan to new heights of enjoyment.

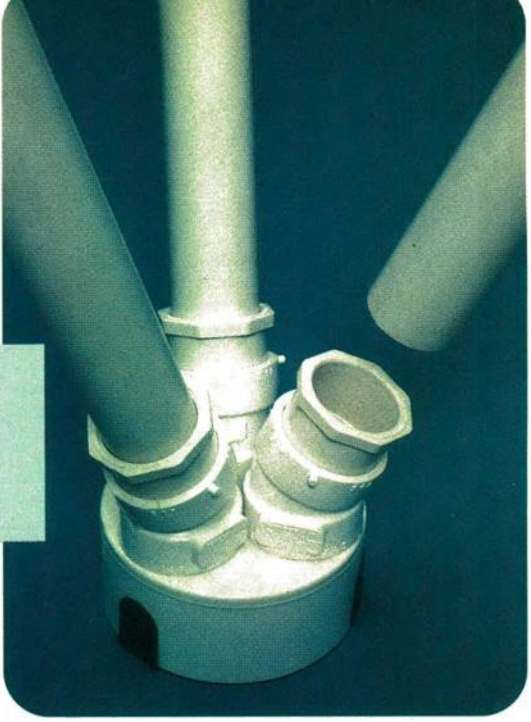
by Stu Ekstrand

ASTROPOD PARTS LIST

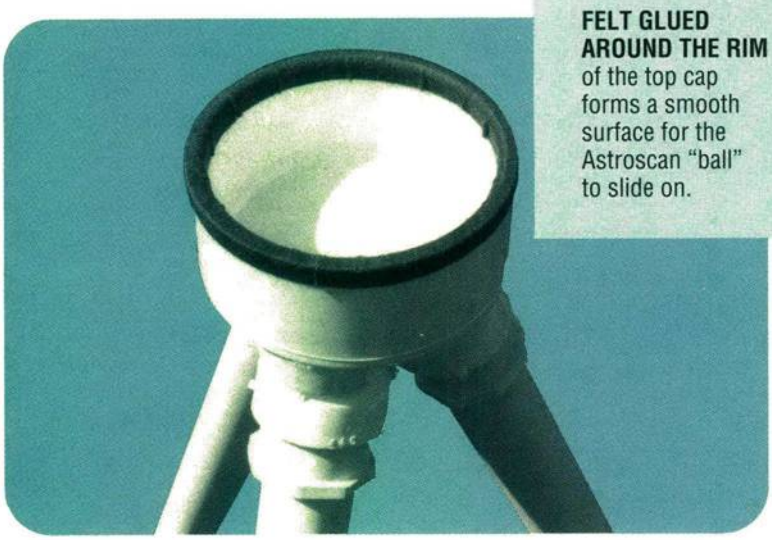
- **1** – 4-inch diameter PVC end cap
- **3** – $1\frac{1}{2}$-inch, $22\frac{1}{2}^\circ$ PVC elbow joints
- **3** – $1\frac{1}{2}$-to-$1\frac{1}{4}$-inch PVC adapters
- **3** – $1\frac{1}{4}$-inch PVC end caps
- **1** – 10-foot length of $1\frac{1}{4}$-inch PVC pipe (cut into three 40-inch lengths)
- **1** – tube of PVC cement
- **1** – package of adhesive felt



THE TRIPOD HEAD is made of three elbow joints glued to an end cap 4 inches in diameter.



THE TRIPOD LEGS are plastic pipes that slide into the elbow joints each time you assemble the Astropod.



FELT GLUED AROUND THE RIM of the top cap forms a smooth surface for the Astroscan "ball" to slide on.

Edmund Scientific's Astroscan 2001 has proven to be one of the most popular telescopes on the market. Its simplicity has made it a great choice for many beginners and for those looking for a portable second telescope.

However, the Astroscan is not without its inconveniences. Although it comes with a stand for placing the Astroscan on a tabletop or car hood, using it in this fashion usually proves to be a little awkward.

The Astroscan comes with a $\frac{1}{4}$-20 socket that enables it to attach to any tripod but this, too, is unsatisfactory. For one thing, you need a very heavy and therefore expensive tripod to hold the Astroscan steady. The other drawback is that you then lose the smooth swiveling motion of the ball-and-socket base that is the hallmark of the Astroscan's simplicity.

Seeking a compromise, I wanted a tripod for my Astroscan that would allow me to swivel the telescope just as if it were placed on its tabletop base. My solution is the "Astropod."

The Astropod design provides a simple, lightweight, but solid tripod that allows you to raise the Astroscan to a convenient height and to get at the eyepiece no matter where in the sky the scope is aimed. Best of all, the design uses materials that cost no more than $20 and take less than an hour to assemble.

The major components are PVC plastic and can be found in the plumbing department of any good-sized hardware store. The only tools you need are a hacksaw, a small file, and some sandpaper.

Here's what you do:

Step 1: Take the large 4-inch end cap that the scope will sit on and file the small mold marks off the inside of the rim. This will make a smooth bearing surface around the inside of the cap.

Step 2: Invert the cap and position the three $22\frac{1}{2}$° elbows so that they touch each other and all face outside. Position each elbow so that the end with the "flats" is in contact with the cap.

Step 3: Cement a $1\frac{1}{2}$-to-$1\frac{1}{4}$-inch adapter into each elbow.

Step 4: Invert the cap and cut a 1-inch wide strip of adhesive felt and stick it around the outside of the rim to a depth of about $\frac{1}{2}$ inch; then fold the excess into the center of the cap to form a felt surface around the entire rim.

Step 5: Clean up all cuts with sandpaper and then cement an end cap onto each of the legs. These form the feet.

Step 6: Insert the legs into the adapters and you're ready to go. I've specified legs 40 inches long, but they can be any length.

If you want a permanently assembled Astropod, you can eliminate the $1\frac{1}{2}$-to-$1\frac{1}{4}$-inch adapters, substitute $1\frac{1}{2}$-inch pipe and end caps for the legs, and then cement the legs directly into the elbows. There isn't a deep enough socket in each elbow to hold a $1\frac{1}{2}$-inch pipe unless the pipe is cemented in permanently.

The result of this project is an inexpensive tripod that won't rust and matches the Astroscan in simplicity and convenience. ☐

Stu Ekstrand is a long-time amateur astronomer and member of the Wehr Astronomical Society in Milwaukee.

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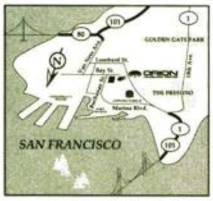

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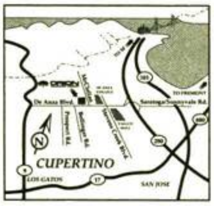

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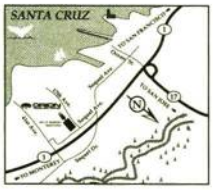

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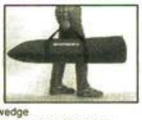

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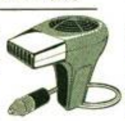

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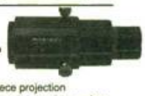

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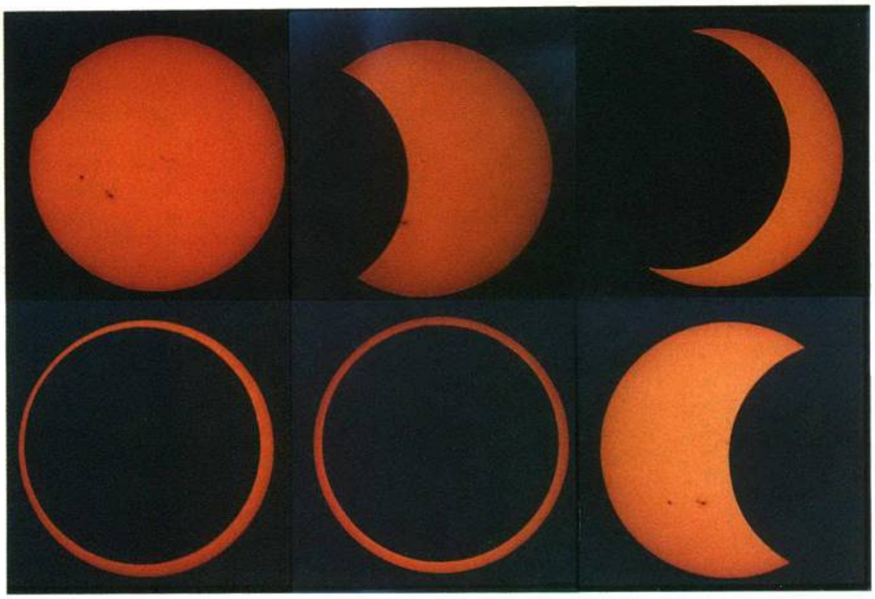
A DIFFERENT KIND OF ECLIPSE

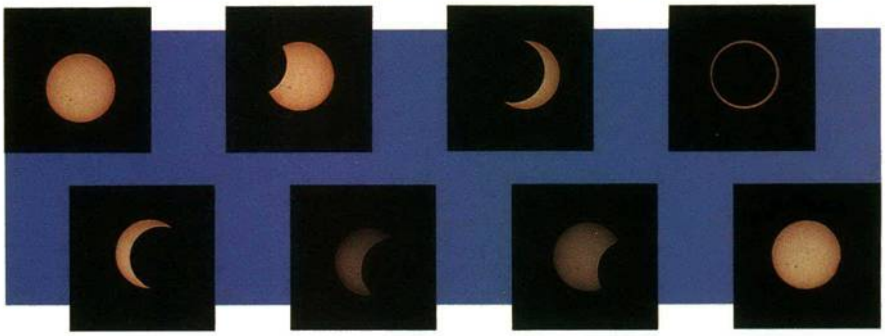
No — it's not the one you're thinking about. The total eclipse that just sent the Moon's shadow sweeping across Hawaii and Mexico is another story yet to come. This story is about the *other* eclipse, the annular, or ring eclipse, visible from Australia and New Zealand on January 15, 1991.

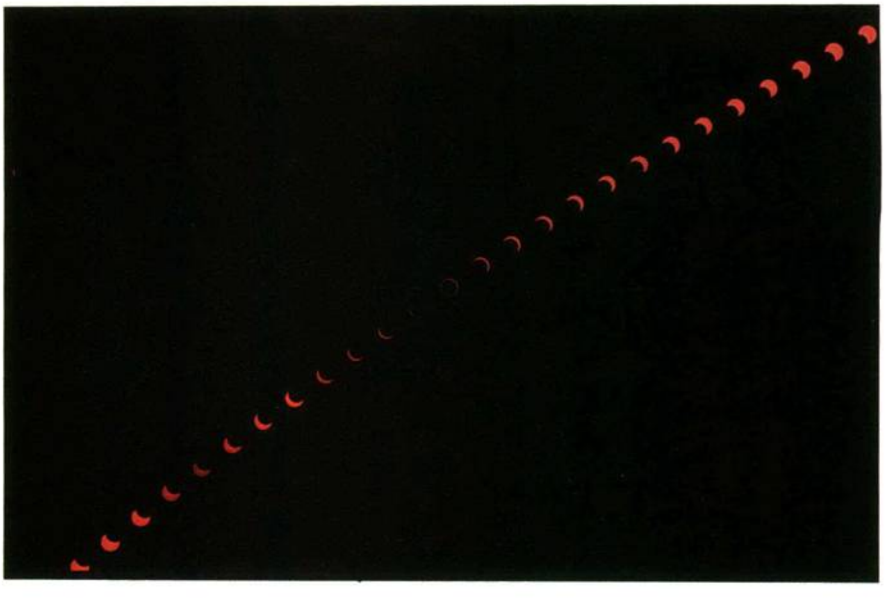
"The annular eclipse didn't raise much attention among eclipse chasers," says Friedhelm Dorst, an amateur astronomer who traveled from Germany to Medina, New Zealand, to see the event. An eclipse chaser since 1970, Dorst is a 43-year-old math and physics teacher who rarely misses a full-blown eclipse — total or annular. Ring eclipses occur when the Moon is relatively far from Earth and does not fully cover the Sun's disk, thereby leaving a thin, bright ring of sunlight at maximum eclipse.

"Ring eclipses are usually considered less interesting than their counterparts, the total eclipses, which show such magnificent detail in the Sun's corona," remarks Dorst. "However, ring eclipses can be just as much fun as total eclipses. During the May 30, 1984 eclipse, I learned that it's possible to photograph some prominences and perhaps even coronal detail if you photograph an annular eclipse without a filter. Four years earlier, at the August 10, 1980 ring eclipse, I was in Calamarca, Bolivia, and saw someone's photograph that showed a purple arc between the cusps that clearly was not of photospheric origin. The ring eclipses of December 4, 1983 (Kenya), and September 23, 1987 (Japan), yielded stunning results: even thin cumulus clouds could not prevent the chromosphere from shining through."

So who can say that annular eclipses are not as beautiful or awe-inspiring as total eclipses? Certainly not Friedhelm Dorst. Annular eclipses offer a wide range of spectacular phenomena, and besides, you don't have to fight crowds of 125,000 to find the nearest cold drink. — *David J. Eicher*







JANUARY'S ANNULAR ECLIPSE provided viewers in New Zealand with a memorable prelude to this summer's total eclipse. Photos by Paul Rodrell (top) and Luciano Nustrini (center and bottom).

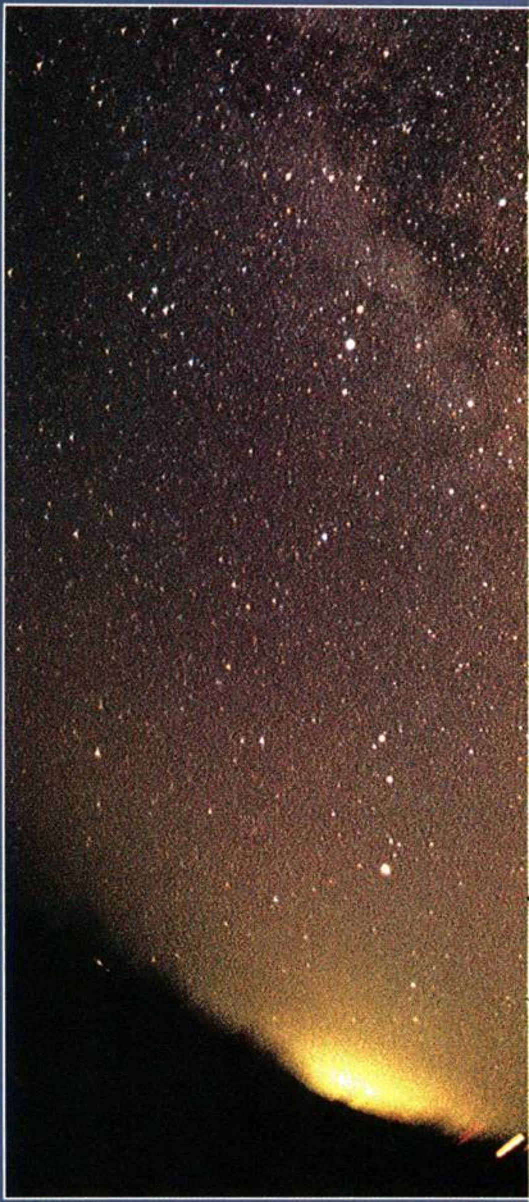
TO THE HEART OF THE MILKY WAY

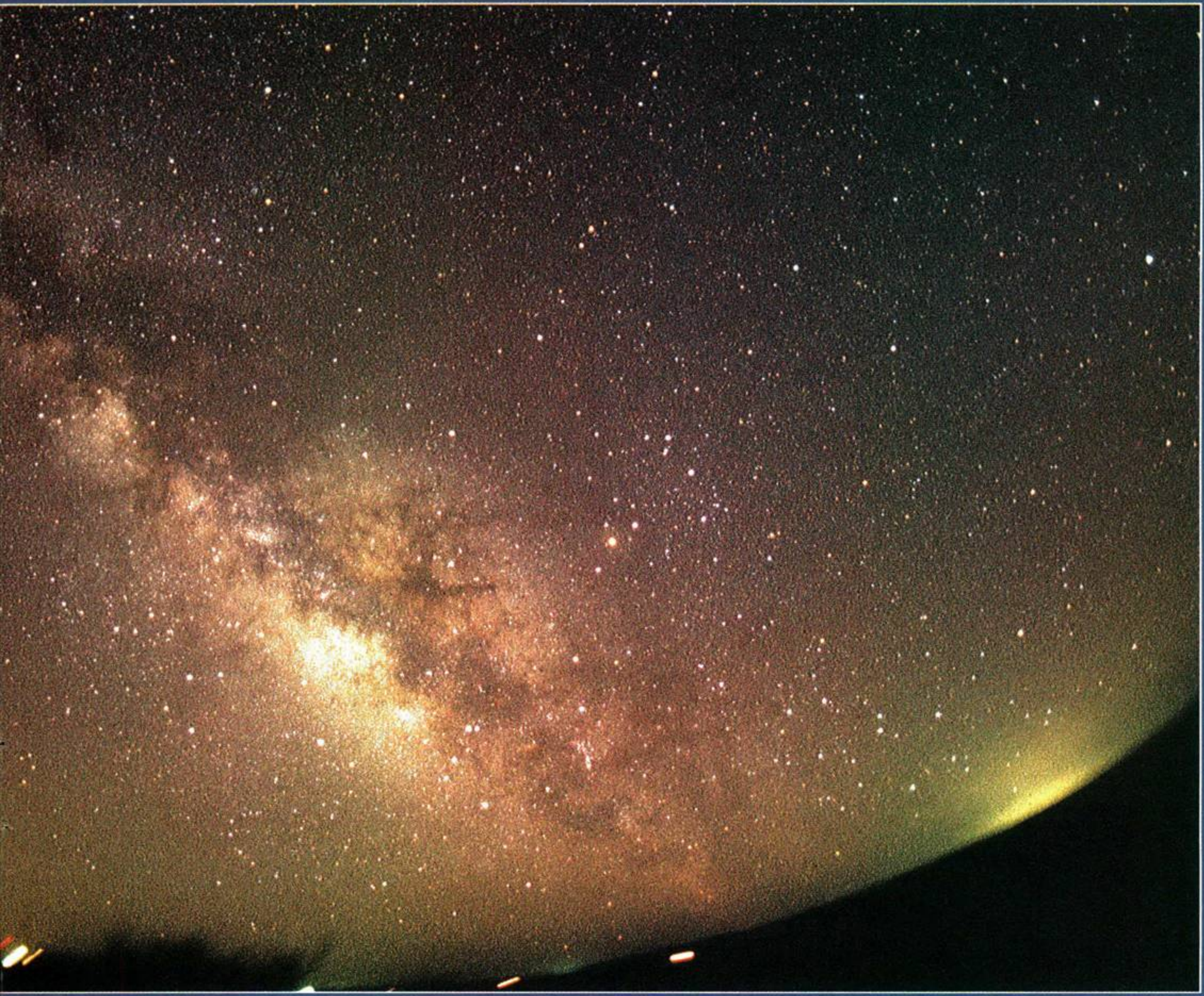
During summer and early autumn, the great glowing arch of the Milky Way stretches across the evening sky. It is an average spiral galaxy seen from within, from a point about 30,000 light-years from the center. We cannot see the galactic center, however, the bright glow we see comes from thousands of unresolved stars in the Sagittarius arm of the Galaxy, a mere 6,000 light-years away. The galactic center, five times more distant, lies hidden, obscured by gas and dust. Michael Terenzoni's fisheye lens photo of the Milky Way (right) wins this month's $100 "Best Astrophoto" award. Terenzoni used a 16mm f/2.8 lens, Fujichrome 1600D film, and a 10-minute exposure from his observing site outside Tucson.

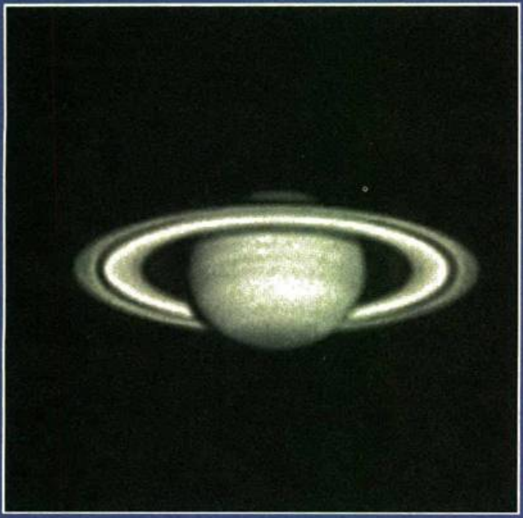
The greatest globular cluster orbiting our Galaxy is Omega Centauri, recorded by Michael Stecker with a 14-inch SCT (below). Stecker used hypered Fujichrome Super HG 400 film and exposed for 45 minutes at f/6.

Closer to home, Hawaiians on April 6 witnessed the spectacular re-entry of the external tank from the space shuttle Atlantis. Paul Sears of Naalehu recorded the tank's disintegration in a series of photographs (left). The 66,000-pound tank "turned into thousands of brightly colored particles and left a trail of smoke behind," according to Sears.

On the CCD imaging front, Donald C. Parker of Coral Gables, Florida, recorded with his 16-inch Newtonian scope and SpectraSource Lynxx-PC camera a series of Saturn images on May 18 (opposite page, bottom). The color image is a composite of three one-color images processed by Richard Berry using his ColorPIX software. The black and white image is a single frame processed to show maximum detail.







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10.1 inch $345.00

"Careful star-testing of the 10.1" Odyssey Compact I received last March and of the 10.1" my neighbor Doug Barnes picked up in mid-October suggests a high level of quality control which is astonishing. Diffraction patterns are virtually interchangeable, and both scopes show textbook optical results (both in-focus and out-of-focus)."
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"In amateur astronomy for over 35 years and I have seen my share of all kinds of telescopes, good and bad. To say the least, the Odyssey 1 outperforms any thing that I have seen!!"
Richard Ziegler, Maumee, Ohio

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"I've only had a chance to view once so far, but am thoroughly thrilled with it. Viewing from a (Santa Barbara, Ca.) residential front yard, the Orion Nebula was indeed a treat – reddish tinges on the predominating green, with many subtle wisps and lanes very clear. The Andromeda Galaxy was surprisingly bright, as was its companion." David Broad, Santa Barbara, Ca.

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CCD AUTOGUIDING SOFTWARE

CCDTRACK, *Santa Barbara Instrument Group, 1482 East Valley Road, #J601, Santa Barbara, CA 93108, (805) 969-1851. $149. Version 2 reviewed.*

CCD autoguiders are revolutionizing deep-sky photography. When attached to a dual-axis drive mount, an autoguider can sense guide star motions and automatically tweak the mount in right ascension and declination to ensure that stars record on film as pinpoint images and not as trails.

The best-known CCD autoguider is the ST-4 model from the Santa Barbara Instrument Group. The standard ST-4 package includes a low-cost CCD camera, a hardware interface, and a software package for camera operation and simple image processing.

To extend the autoguiding capabilities of the standard ST-4, Santa Barbara Instrument Group has introduced CCDTRACK, an IBM-compatible software package first developed to guide the 48-inch Schmidt camera at Palomar Mountain. To use CCDTRACK you need an IBM or compatible computer at your telescope.

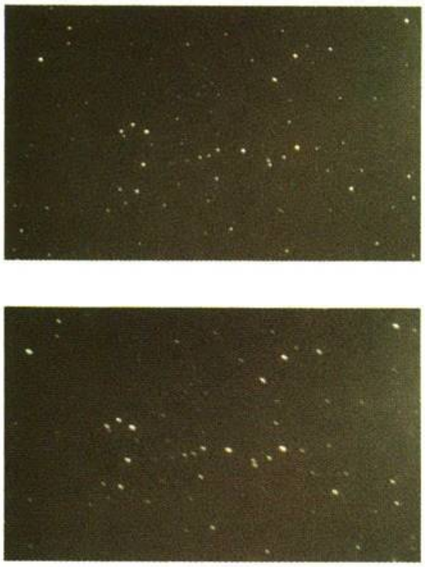
Why use the CCDTRACK software? One reason is that the software allows you to guide on any star or object in the field, making it possible to guide on comets or on faint stars. By comparison, when used as a stand-alone guider, the ST-4 guides only on the brightest star in the field. Another good feature of CCDTRACK is the visual display of the guide star and a crosshair for reference, as well as graphical plots of accumulated tracking errors. You can also input your telescope's focal length and aperture so that all the data will display in arcseconds.

CCDTRACK operates in either of two modes, tracking on a point source (the normal mode) or along a line of screen pixels over time (useful for taking spectra). When operating, the CCDTRACK software first acquires an image using the CCD camera and then downloads the image to the computer. The computer calculates the difference between the original position and current position of the guide star being tracked. The computer then applies the correction by activating the right ascension and declination drives to bring the star image back to its original position.

After focusing (a simple process that takes 5 minutes), the CCDTRACK software must be calibrated to the declination of the object being photographed. Although the ST-4 hardware box has a "Calibrate" button that automatically calibrates the ST-4 when used in the stand-alone mode, the CCDTRACK software, for all its power, lacked such an automatic feature. We ended up creating a reference table that gives the proper calibration parameters for a set of declinations.

Starting a guiding sequence consists of downloading one full image to the computer screen, where you then select the guide star. On a slower computer such as a PC-XT (the first type we tried) or on telescope drives with fast periodic error, it is possible to lose the guide star between the time you acquire the image and the time you start the guiding sequence. To get around this we ended up using the ST-4 in stand-alone tracking mode during the interval the image was being transferred to the computer and the start of the tracking sequence. This allowed us to select a guide star on the screen and start the tracking process at our leisure.

How well does CCDTRACK actually



PERFECT STAR IMAGES should be the result of using a CCD autoguider. With the ST-4 used as a stand-alone guider (top photo) that was the case. But when used with the optional CCDTRACK software (bottom photo), tracking errors were not corrected adequately. Both photos of a star field near Jupiter are 10-minute exposures on Kodacolor 400 with a Meade LX-6 Schmidt-Cassegrain at f/6.3. Photos by Mark d'Antonio and John Zack.

track? When used as a stand-alone autoguider, the ST-4 applies drive corrections about once every second. With all parameters set the same, the CCDTRACK program took approximately four times longer to apply corrections. With the stock Meade LX-6 telescope we used for the test, this slow response time resulted in poorly guided photos — by the time it applied a correction the guide star had moved even farther and the amount of correction needed to be even greater. The author of the CCDTRACK program as well as Richard Schwartz, president of Santa Barbara Instruments, both suggested speeding up the tracking response by using a faster computer. We tried both AT-class and 386-based PS/2 computers, but found we could not duplicate the tracking performance of the ST-4 alone. Even a 20MHz PS/2 computer increased the response time of CCDTRACK by only 25 percent, making it still three times slower than a stand-alone ST-4. With the ST-4 alone, for example, we were routinely able to achieve guiding accuracies of roughly 2 to 3 arcseconds. With CCDTRACK and a computer controlling the guiding, the tracking accuracy was no better than 5 arcseconds.

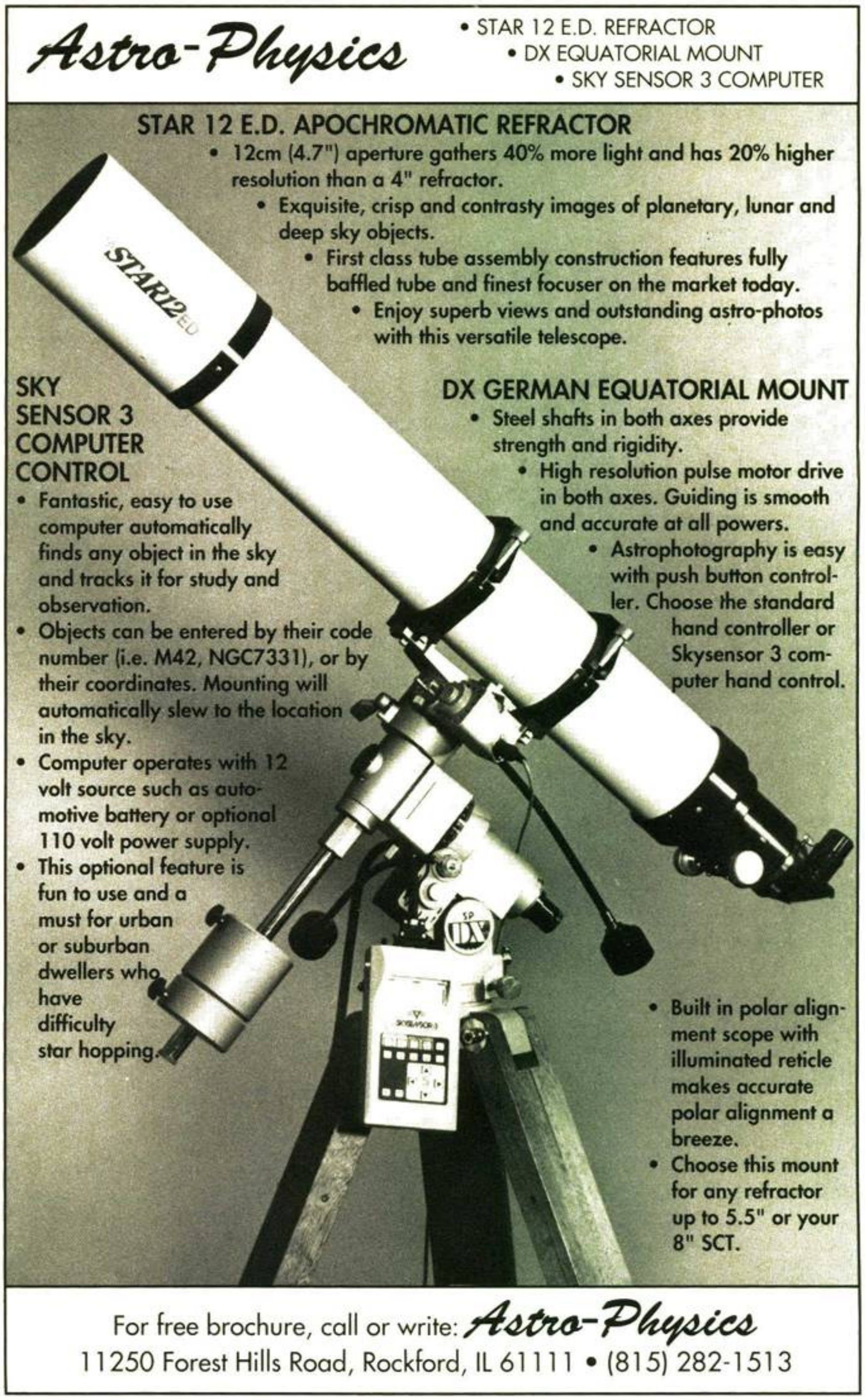
Part of the problem can be attributed to the fact that our test telescope had a substantial periodic error in the drive to begin with (nearly 100 arcseconds) and had no periodic error correction. Due to CCDTRACK's slow response it had problems compensating for the large, sudden drive errors. A smooth drive equipped with a periodic error correction circuit is essential for anyone using CCDTRACK.

Make no mistake — the ST-4 is a superb performer as a stand-alone autoguider. However, we feel that the CCDTRACK software as it stands now (we reviewed version 2) needs refinement — *it is too slow* for use on telescopes with anything but superb drive systems.

— Marc D'Antonio and John Zack

SOFTWARE NEWS

Update on STSORBIT: David Ransom, the author of this free satellite-tracking program (first noted in the April 1991 issue) writes that readers interested in acquiring a copy should download it from Ransom's bulletin board system. Contact: RPV ASTRONOMY BBS, Rancho Palos Verdes, California, (213) 541-7299. STSORBIT can also be downloaded from NASA Spacelink BBS, Huntsville, Alabama, (205) 895-0028, where it is listed under the Classroom Materials section, IBM PC programs. ☐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We've taken Meade's renowned 2080 Basic 8 inch Schmidt-Cassegrain telescope & upgraded it for astrophotography & easy field use. Just look at the features....

- *World famous 8 inch 2000mm F/10 optics*
- *Meade LX worm gear drive system*
- *Meade #43 drive corrector - for easy RA drive adjustment & 12v DC operation*
- *Meade 25mm (80X) & 9mm (220X) MA eyepieces*
- *6x30 finderscope* · *1¼" diagonal*
- *Wedge & adjustable field tripod*

VERY LIMITED SUPPLY **$1039.95**

List Price Over $2000

2080 Enhanced MCOG same package as above but with multi-coatings **1149.95**

2045D

THE SCHMIDT-CASSEGRAIN YOU CAN TRUELY TAKE ANYWHERE

4 inch 1000mm F/10 optical tube with MCOG multicoatings, equatorial fork mount with reversible DC motor drive & table tripod, 5x24 finder, 1¼" star diagonal, 25mm eyepiece, AA battery pack **$619**

F/6.3 WIDE-FIELD SCHMIDT CASSEGRAIN TELESCOPE SALE

The world's finest wide field Schmidt Cassegrain Telescopes - so good even **NASA** uses them! Get a 59% wider field of view & a 60% reduction inexposure times than with a traditional 8" SC scope.

PREMIER 2080/56

Meade's renowned 1200mm F/6.3 8 inch 1200mm F/6.3 optical tube matched to an ultra,precise LX6 drive system and supplied with ECC hand controller, DEC motor, 26mm Super Plossl eyepiece, 9x60 RA polar illuminated finder, 2" diagonal, wedge, tripod & case **$1699**

PREMIER 2120/56

Meade's 1600mm F/6.3 10 inch 1200mm F/6.3 optical tube privides 25% more light gathering than a comparable 8 inch tube. Add to that an ultra, precise LX6 drive system and supplied with ECC hand controller, DEC motor, 26mm Super Plossl eyepiece, 9x60 RA polar illuminated finder, 2" diagonal, wedge, tripod & case & you have the best value in a large aperture wide field telescope. **$2149**

Meade List Price Over $4500

PREMIER SERIES

PREMIER SERIES *All Complete Factory Packs*	**2080** *8 Inch*	**2120** *10 Inch*
40 SD F/10 **Smart Drive**	**1537**	**1987**
46 SD F/6.3 **Smart Drive**	**1667**	**2067**
50 F/10	--	**2087**
56 F/6.3 ***SPECIAL***	**1699**	**2149**
50 SD F/10 **Smart Drive**	**1827**	**2299**
56 SD F/6.3 **Smart Drive**	**1989**	**2399**
70 SD F/10 **Smart Drive**	**CALL**	**CALL**
76 F/6..3	--	**3799**
76 SD F/6.3 **Smart Drive**	**CALL**	**CALL**

Super Wedge option for 2120 Premiers **219.95**

10 INCH SCOPE SALE

NOW YOU CAN ENJOY ALL THE BENIFITS OF A 10 INCH APERTURE TELESCOPE AT AN 8 INCH PRICE !

PREMIER 2120/30

WOW!

10" SCHMIDT-CASSEGRAIN

Never has so much telescope cost so little! This is the last chance to get a fully equipped Meade 10" Schmidt-Cassegrain at this price.

COMPLETE FACTORY PACKAGE INCLUDES:
10 inch 2500mm F/10 optical tube, MCOG multi-coatings, microprocessor controlled LX6 drive system, 25mm MA eyepiece, 8x50 finderscope, 1¼" diagonal, AC adapter DC battery pack, case wedge & tripod **$1579**

2120 LX5 F/10

10" SCHMIDT-CASSEGRAIN

The 2120 LX5 is an excellent all around scope. Its MCOG multi-coated optical tube provides excellent images & its sophisticated LX5 drive system makes taking stunning pictures easy.

COMPLETE FACTORY PACKAGE INCLUDES:
10 inch 2500mm F/10 optical tube, microprocessor controlled LX5 drive system, LX5 hand controller, 26mm SP eyepiece, 8x50 finderscope, 2" diagonal, AC adapter DC battery pack, case wedge & tripod **$1799**

DS-10A DEEP-SPACE

10" EQUATORIAL NEWTONIAN

Get the most bang for your buck with the Meade DS-10A. This rugged yet high quality optical instrument offers an extremely fast F ratio of F/4.5 making it ideal for deep space observation & photography.

COMPLETE FACTORY PACKAGE INCLUDES:
10 inch 1150mm F/4.5 optical tube, 2"/1¼" rack & pinnion focuser, equatorial mountwith RA motor, low profile pier & stand 25mm MA eyepiece **$679**

MEADE ACCESSORIES

#712 Dew Shield 8" (2080)	**94.95**
#710 Dew Shield 10" (2120)	**107.95**
ECC Hand Controller (Premier 2120/30)	**239.95**
#39 DEC Motor (LX5, Premier 30/36/40/46)	**88.95**
#1200A Focus Motor (LX5, Premier)	**194.95**
#9068/#9070 Digital Readout	**289.95**
#9008/#9010 CAT Computer Aided Telescope for Premier & LX6 scopes	**833.95**
CAT-COM RS-232 interface	add'tl **157.95**
#62 Schmidt Cassegrain Camera Adapter	**38.95**
Basic Camera Adapter .96" (Refractor)	**38.95**
Basic Camera Adapter 1¼" (Refractor)	**34.95**
Variable Projection Camera Adapter 1¼"	**49.95**
#106 Off-Axis Guider System (2080/2120)	**159.95**
Telecompressor System f/above	**57.95**
Wide-Field Adapter System (2080/2120)	**107.95**
Eyepiece Projection Photography Kit Includes: EP Holder, Tele-Extender & T-ring	**79.95**
Terrestial Viewing Kit Includes: erect image diagonal & holder	**74.95**
#928 45° Erect Image Diagonal	**48.95**
# 929 2" Giant Diagonal (w/1¼" adapter)	**154.95**

MANY MORE MEADE ACCESSORIES IN STOCK

4420 Newtonian

The Meade 4420 is the perfect telescope for the beginner. Its' large 4½ inch aperture optical tube & equatorial mounting make it ideal for planetary, deeper space observation or astrophotography.

Special Holiday Sale Price.......... **$319**

MTS-SN6 MCOG

SCHMIDT NEWTONIAN TELESCOPE

This Meade MTS-SN6 offers a superb 6 inch 750mm F/5 optical tube. It features **MCOG** multi-coated optics #788 motor drive, 1¼/2" focuser, 25mm eyepiece & sturdy MTS equatorial mount with pier.

Meade List Price
Focus Camera Sale Price **$599**

MTS-SN6 LX3	
as above with LX3 Drive	**729**
#66A Dec Arm	**43**
6x30 Finder	**43**

826C NEWTONIAN

The Meade 826C is the #1 choice if you are looking for a quality 8 inch Newtonian reflector. Its' 1200mm F/6 diffraction limited optical tube provides optimum imaging of objects ranging from the planets to galaxies & nebulae. Its motorized equatorial mount permits easy tracking for viewing or astrophotography.

TELESCOPE INCLUDES:
Optical tube, 2"/1¼" rack & pinnion focuser, equatorial mountwith RA motor, 8x50 finder, pier & stand, 25mm MA eyepiece **$824**

DS-16AB 16" F/4.5 Newtonian as DS-10A with Sealmaster Mount Bearings **$1767**

MEADE REFRACTORS

223S - THIS MONTH'S SPECIAL!

This 2.4" 700mm F/11 refractor with 2 eyepieces, diagonal, finder, barlow lens & tripod. Ideal first scope for the kids or even better use as a inexpensive guidscope **$84.95**

290 2.4 Inch Equatorial	**214.95**
291 2.4 Inch Deluxe Equatorial	**269.95**
312 3.1 Inch Alt-Azimuth	**324.95**
323 3.1 Inch Equatorial	**437.95**

MEADE EYEPIECES

Meade Series 4000

SUPER PLOSSL - Up to 52° Apparent Field

6. 4, 9.7, 12.4, 15, 20, 26mm 1¼"	**64.95**		
32mm 1¼"	**84.50**	40mm (44°AF)	**87.50**
56mm 2 inch	**158.50**		
2X Barlow 1¼" #140	**62.10**		

SUPER WIDE ANGLE - 65° Apparent Field

13.8mm 1¼"	**108.95**	18mm 1¼"	**117.95**
24.5mm 1¼"	**123.95**	32mm 2"	**183.50**
40mm 2 inch	**253.50**		

ULTRA WIDE ANGLE - 84° Apparent Field

4.7mm 1¼"	**122.95**	6.7mm 1¼"	**147.95**
8.8mm 1¼/2"	**172.95**	14mm 1¼/2"	**202.50**

CELESTRON

CLASSIC 8 STARBRIGHT

Classic 8 is the latest in a long line of fine Schmidt-Cassegrain telescopes from the company that pioneered top quality comercial scopes. Its' fine 8 inch 2032mm F/10 optical tube is further enhanced by the application of Celestron's unique Starbright coating to provide optimum light transmission. Add to that a rugged equatorial mount and accurate motor drive and you have the perfect observing package for any astronomer, pro and novice alike.

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COMPLETE WITH BASE & BATTERIES
SPECIAL $37.95

FOCUS CAMERA'S EXCLUSIVE PACKAGE INCLUDES:

- 8 inch 2032mm F/10 optical tube with Starbright coatings for enhanced light transmission
- Celestron 30mm Plossl Eyepiece (instead of the lower grade Kellner eyepiece usually supplied)
- Celstron's latest model heavy duty adjustable field tripod (this is usually an additional cost option)
- Rugged swing fork equatorial mounting system with precise AC motor drive for tracking
- 6 x 30 Finderscope & 1¼" Star Diagonal
- Adjustable equatorial wedge

List Price Over $2400
FOCUS CAMERA'S PRICE $1199

SUPER POLARIS C8

***COMPLETE PACKAGE INCLUDES*:**
8 inch 2032mm F/10 Schmidt-Cassegrain optical tube, Super Polaris equatorial mount with slow motion controls, 5x24 finder, 1¼" diagonal 25mm Kellner eyepiece & trunk case.
List Price Over $1700 **$969**

SUPER POLARIS C8 STARBRIGHT $1167

POWERSTAR PEC

The new Powerstar PEC features Celestron's famed 8 inch Schmidt Cassegrain optics with **Starbright** coatings, PEC periodic error correction DC servo drive system & Byers worm gear for improved tracking accuracy, 30mm Plossl eyepiece, 6x30 finderscope 1X" Star Diagonal, case, wedge & rubberized tripod **$1539**

ULTIMA 8 PEC

The state of the art 8 inch Schmidt Cassegrain telescope from Celestron. It features a rugged swing fork mount with carrying handles for ease of set up, a massive cast polar shaft with 4" ball bearings, 7½" Byer's worm gear drive & PEC periodic error correction drive system for the ultimate in drive accuracy.

COMPLETE FACTORY PACKAGE INCLUDES:
8 inch 2032mm F/10 optical tube with **Starbright** coatings, PEC drive system with hand controller, 30mm Plossl & 7mm Ortho eyepieces, 8x50 Polar illuminated finderscope, 1¼" Star Diagonal, case, wedge & rubberized tripod **$1889**

ULTIMA 11 PEC

The ultimate 11 inch scope now with PEC drive.
CALL FOR PRICE AND AVAILABILITY

C60E REFRACTOR

- 2.4" 800mm F13 Optics
- Equatorial Mount w/Tripod
- 5x20 Finder, 32x Eyepiece Star Diagonal, Moon Filter

Celestron List Price $498.00 **$197**

C4.5 NEWTONIAN

4½" Equatorial Newtonian w/Tripod, Eyepiece & Finder **$434**

Firstscope 80 3.1" Refractor	**469.95**
Super Polaris C80	**614.95**
Super Polaris C6 Newtonian	**719.95**
Super Polaris C102	**1079.95**

CELESTRON ACCESSORIES

AC adapter (PEC telescopes	**27.95**
Counterweight set 8"	**49.95**
DC inverter - lets Classic 8 to work on 12v DC	**78.95**
DEC or Focus Motor (Classic/Ultima 8)	**79.95**
DEC or Focus Motor (PEC Scopes)	**117.95**
NEW **F/6.3** Focal Reducer/Correcter	**147.95**
Off-Axis Guiding System w/eyepiece	**129.95**
Vibration Suppression Pads	**38.95**
NEW Micro Guide Eyepiece	**147.95**
NEW Advanced Astromaster Computer	**629.95**
C4.5 Motor Drive	**167.95**
Single Axis Motor Drive SP-C8/6/80/102	**159.95**
Dual Axis Motor Drive SP-C8/6/80/102	**267.95**
Polar Axis Finder SP-C8/6/80/102	**74.95**
Piggyback Mount SP-C6/80/102	**39.95**
Piggyback Mount all 8" scopes	**36.95**

CALL FOR COMPLETE DISCOUNT PRICE LIST

CELESTRON EYEPIECES

ORTHOSCOPIC - Up to 45° Apparent Field

5, 6, 7, 9, 12mm .96"	**36.95**
5, 6, 7, 9, 12,mm 1¼"	**47.95**
25mm 2" Orthoscopic	**129.95**
30mm Plössl 1¼" 50° Aparent Field	**69.95**
2X Barlow 1¼"	**40.95**
2X Barlow 2"	**94.95**

ULTIMA SERIES EYEPIECES

5, 7.5, 12.5, 18, 24mm 1¼"	**62.95**
30, 35, 42mm 1¼"	**96.95**
45, 60mm 2"	**177.95**
15, 19, 23mm 1¼" Wide-Angle	**127.95**
2X Barlow Ultima Series 1¼"	**68.95**

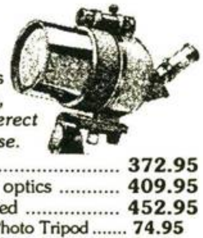
CELESTRON FILTERS

These fine Celestron eyepiece filters can be used with most telescope from most manufacturers

.96 Inch:	#1A Skylight, #12 Yellow, #21 Orange, #23A Red, #38A Blue,#56 Green, #80A Blue, #96 50% or 25% Neutral Density
1¼ Inch:	#1A Skylight, #8 #12 #15 Yellow, #21 Orange, #23A #25 Red, #38A Blue, #47 Violet, #56 #58 Green, #80A #82A Blue, #96 50% 25% or 13% Neutral Density

Any of the above filters	each **12.95**
Any Four Filters	**47.95**
.96 or 1¼ inch Polarizer	**14.95**
LPR A 1¼" eyepice	**78.95**
LPR B (rear cell)	**108**

C90 SPOTTING SCOPES



- 3½" 1000mm F/11 Celestron optics.
- Use as a spotting scope telescope or camera lens

Includes: 33x eyepiece, 8x20 erect finder, 45° erect prism, fitted carrying case.

C90 Basic	**372.95**
C90 MC with multicoated optics	**409.95**
C90 Rubberized Multicoated	**452.95**
Camera Adapter .. **31.95** Photo Tripod	**74.95**
Eyepieces: 10, 16, 18, 25, 40mm Kellner	**32.95**

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Spotting Scopes

97E WITH CASE

- 3½"1000mm F/11 optics
- 5x21 erecting image finder
- 45° erecting diagonal
- 40x Meade eyepiece

$317

97ER-2 3½ inch spotting scope as above but with rugged rubberized finish **$367**

Eyepieces (111x, 80x, 55x, 25x)	**37.95**
Camera Adapter .. **34.95** Hard Case	**44.95**
Hybrid Diagonal allows use of 1¼ eyepieces	**48**

2045S 4" SPOTTING SCOPE

NEW 4 inch Schmidt Cassegrain with 40X eyepiece, 1¼" erecting diagonal& finder **$474**

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20x80 NEW Multicoated & Rubberized w/BAK 4 prisms,tripod adapt & case ... **289.95**

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8x56 Ultima Series	**189.95**
10x50 Ultima Series	**199.95**
11x80 Multicoated w/case & tripod adapt.	**293**
15x80 Multicoated ***NEW***	**298.95**
20x80 Multicoated w/case & tripod adapt.	**304**

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7x50 MT-SX w/carry case	**329.95**
7x50 MTR-SX Rubber Armored	**349.95**
7x50 MTRC-SX Armored w/compass	**409.95**
10x70 MT-SX w/carry case	**407.95**
14x70 MT-SX w/carry case	**429.95**
7x50 FMT-SX w/carry case	**384.95**
7x50 FMTR-SX Rubber Armored	**429.95**
7x50 FMTRC-SX armored w/compass	**499.95**
10x70 FMT-SX w/carry case	**459.95**
16x70 FMT-SX w/carry case	**569.95**
Tripod Adapter	**14.9 5**

JMI - JIM'S MOBILE

Motodec DEC Motor for Meade 2080/2120 telescopes	**74.50**
Motofocus Focus Motor (Meade SCT)	**78.50**
DSC-MAX Setting Circles	**CALL**
NGC-MINI MAX Computer System	**569**
NGC-MAX Computer System	**CALL**
NGT-16/18/25 Telescopes	**CALL**

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A Starhopper's Guide to Messier Objects, by Lenore F. Powell, $6.95.
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New Astronomy Products

1 Project STAR Activity Kits

A variety of hands-on activity kits is available from Project STAR (Science Teaching through its Astronomical Roots), a program to encourage astronomy in school curricula. These activities have been tested with thousands of high school students nationwide. Activity kits include materials and instructions for making a 7-inch-diameter celestial sphere, a holographic diffraction grating, and a simple 16x telescope (pictured). Teachers can also purchase the STAR activity manual that contains 21 projects. Write for further information.

Learning Technologies, Inc., 59 Walden Street, Cambridge, MA 02140, (800) 537-8703 (from within Massachusetts call (617) 547-7724).

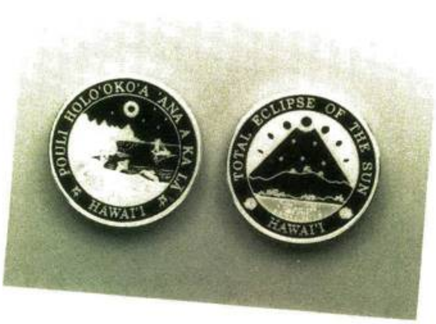
2

This set of five VHS videocassettes documents the development of the NASA space program from Mercury to the shuttle. Cassettes range from 95 to 125 minutes in length and contain compilations of official NASA documentaries produced over the last 30 years.

United States Film Corporation, 75-313 14th Green Drive, Indian Wells, CA 92210, (619) 773-9169, FAX: (619) 773-0474. Each volume: $24.95 plus $4 shipping and handling for one tape (each additional tape $1.50 each S&H), set of 5 tapes: $99.75 plus $10 S&H. California residents add sales tax.

3 Eclipse Medallions

Commemorating the July 11 eclipse, these medallions are available in 1 troy ounce pure silver, 1 troy ounce 24K gold, and 1/10-ounce gold jewelry pieces. A portion of the proceeds from the sale of these medallions goes to the Bishop Museum, Honolulu.



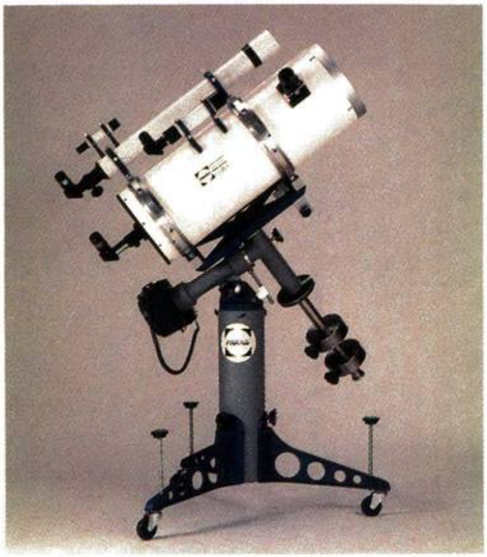
Honolulu Mint, P.O. Box 10578, Honolulu, HI 96816, (808) 737-0303. Silver: $29.50. Gold: $795. Gold jewelry: $195 to $898.

This department presents new product announcements issued by their manufacturers. The product information is as supplied by the manufacturers or distributors. All prices are suggested retail. Suppliers are invited to send their product announcements to the attention of Alan Dyer.

4 Newtonian/Cassegrain Hybrid Telescopes

Parks Optical is introducing a series of Newtonian/Cassegrain dual f/ratio telescopes. Available in 6-, 8-, 10-, 12.5-, and 16-inch sizes, each model has an f/3.5 Newtonian focus and an f/15 Cassegrain focus. Each telescope features certified optics (hand-figured from fine-annealed low-expansion Pyrex glass), fiberglass tubes, dual-axis motors and drive corrector, and two Parks Gold series 1¼-inch eyepieces.

Parks Optical, 270 Easy Street, Simi Valley, CA 93065, (805) 522-6722, FAX: (805) 582-0292. 6-inch: $1,999, 8-inch: $2,299, 10-inch: $3,399, 12.5-inch: $5,299, 16-inch: $15,500.



5 Low-Cost Binoculars

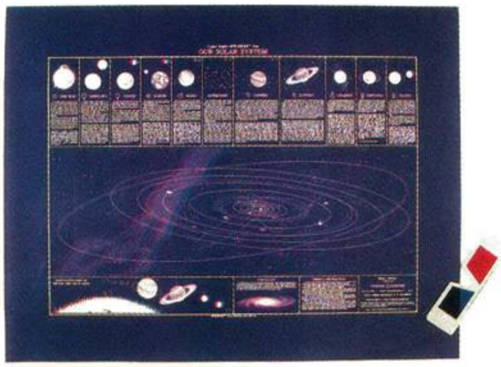
Available in a 10x50 model (with a 5.5° field) and a 20x50 model (with a 3.0° field), these binoculars feature aluminum bodies, a center-focus mechanism, and an affordable price.

John T. Craig, 3114 Jacqueline Road, Wichita Falls, TX 76305. 10x50: $60.00, 20x50: $89. Add $4 shipping and handling in the continental U.S. Texas residents add sales tax.

6 3D Solar System Poster

This unique poster depicts the planets and their orbits around the Sun using the 2-color anaglyph 3D process. Each poster comes with 2 red/blue viewing glasses. Also available is a full-color 2D version of the poster. Both are 22 by 28 inches and are shipped rolled. Plastic laminated versions are also available.

Cygnus Graphic, P.O. Box 32461, Phoenix, AZ 85064-2461. Opti-Relief 3D version: $9.95 (paper), $18.95 (laminated), Luci-Chrome™ color version: $7.95 (paper), $16.95 (laminated).



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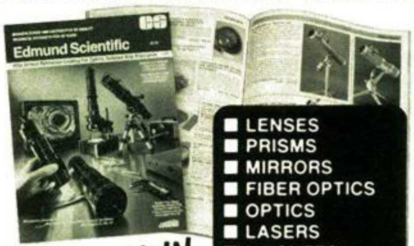

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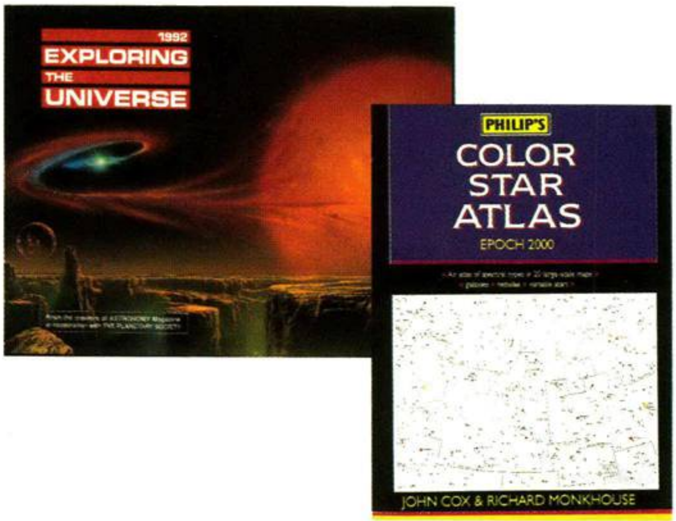

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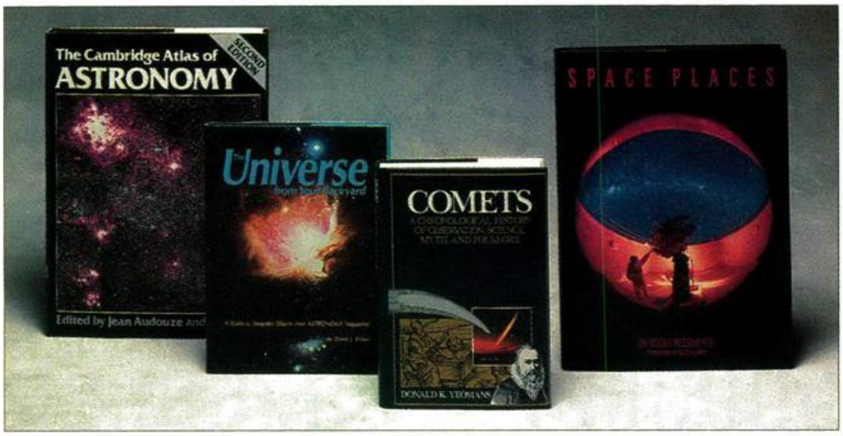

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Messier's Nebulae and Star Clusters, 2nd edition, by Kenneth Glyn Jones, (Cambridge University Press, 1991), ISBN 0-521-37079-5, 414 pages, hardcover, sewn binding, $49.95.

Two hundred years ago, French astronomer and comet hunter Charles Messier published a list of 103 objects he and a colleague, Pierre Méchain, had observed. These objects were chosen because, as seen in the instruments of the time, they resembled comets and might be confused with them. This list, expanded eventually to 110 items, contains many of the sky's most attractive deep-sky objects — galaxies, star clusters, and nebulae. It has become one of the most popular "best hits" in astronomical history and practically every stargazer has spent many dark nights in search of Messier's famous nebulae and star clusters.

The Messier list has been published many times in many forms, but finding background information about each object and Messier himself usually requires looking in many sources. The great virtue of Kenneth Glyn Jones' book, published originally in 1968 and now returned to print, is that it provides loads of good readable information.

The first part of the book covers basic observing techniques, telescopes and mounts, filters, sky conditions, and what the Messier objects are. Then the objects are covered in order starting with M1, the Crab Nebula. Each object gets its own pages with the basic facts of type of object, location, and date of discovery. This is followed by descriptive quotes, mostly written by observers of the pre-photographic era, such as William and John Herschel, W. H. Smyth, and T. W. Webb. These visual descriptions give you a better feel for what the objects will look like through a telescope than any photo will. They also provide a link across the centuries to observers whose equipment was often similar to what we use today.

The coverage of each Messier object includes an eyepiece view and finder chart. If other interesting objects lie nearby, the author tells you something about them as well. To make for easy scanning, Glyn Jones has placed the Messier number (and its NGC number) at the top of each page. I found this very useful and a real time-saver when trying to locate information about an object quickly while at the telescope.

After the descriptive section of the book are brief bibliographic notes on where the observers' descriptions came from. This is followed by biographical sketches on each of the 55 observers quoted. I found this an interesting addition and it rounded out the book nicely. Likewise, no book on Messier would be complete without a biography. The author has included an interesting account of Messier's life and of his friends Méchain and Delisle, and their contemporaries. Glyn Jones has also included Messier's account and drawing of the Great Nebula in Orion (M42), as first published in 1771 in the *Mémoirs de l'Academie des Sciences.* He used a 3.5-inch refractor with a 3.5-foot focal length (f/12) at 68 power to observe M42 and most of the other objects in his list. (*That* should encourage small telescope owners!)

At the end of the book you'll find all the Messier objects (given in the order of discovery), sky charts, and photos of each object. Instructions are also given on a simple way to observe the 15 Messier galaxies in Virgo and Coma Berenices.

I found this book to be crammed with facts and observing tips and highly recommend it to anyone interested in deep-sky observing. *Robert Garfinkle*

Observing Books

The Sky, a User's Guide, David H. Levy, (Cambridge University Press, 1991), ISBN 0-521-39112-1, 295 pages, hardcover, $24.95.

By taking all of the sky as his theme, Levy has written a low-key introduction to amateur astronomy for beginners. The impression given is that learning about the sky is fun and rewarding, but is in no sense a duty or a chore. There are plenty of facts and numbers where they are important, but the stress always lies on understanding the celestial objects and making them a part of your intellectual heritage.

Discover Arizona's Night Sky, by Raymond Shubinski, (Arizona Highways, 1991), ISBN 0-916179-30-3, 57 pages, paperback, $7.95.

This offshoot of the colorful tourist magazine provides four seasonal star charts, lots of scenic sky photographs (many of them the camera-on-tripod variety), and a detailed introduction to viewing the night sky for the beginner. A chapter also tells how to visit the observatories in Arizona.

The Under-Standing of Eclipses, by Guy Ottewell, (Astronomical Workshop, 1991), 93 pages, paperback, $12.95.

The title's a pun — Ottewell wants you to understand an eclipse while you're standing under it! To that end he provides many diagrams, charts, and tables and an attractive text explaining how eclipses work, including the July 1991 one and others. Riffling the pages of the book also animates a little flip-movie eclipse.

Deep-Sky Name Index 2000.0, by Hugh C. Maddocks, (Foxon-Maddocks Associates, 1991), ISBN 0-9628305-0-X, 136 pages, wire-bound, $16.95.

You know where to look for the Andromeda Galaxy, but where's the Coathanger? To answer questions like that, this book lists all the common names and synonyms of celestial objects, their home constellation, and their epoch 2000.0 coordinates. You can also look up a constellation (all 88 are included) and see listed the brighter objects that lie within its boundaries.

How to Choose Binoculars, Alan R. Hale, (C & A Publishing, 1991), ISBN 0-9629090-0-9, 145 pages, paperback, $14.95.

This book provides a text that explains how binoculars work, how to choose a pair for various uses, and what specialized terms (such as "twilight factor," "relative efficiency," and so on) mean. It also gives comparative tables listing the models and specifications for binoculars from 26 manufacturers, from Aus Jena to Zeiss.

Photographic Atlas for Supernovae Search, vol. 2, by Manuel López Alvarez, (Editorial Argenta Sarlep, 1991), ISBN 950-9332-60-7, 433 pages, paperback, sewn binding, $39.95.

This book by an Argentinian amateur astronomer contains photographs of 700 galaxies within the declination range 20° south to 20° north. The galaxies are 14th magnitude or brighter and larger than 3' across. The photo pages are blank on the reverse, so the photos (printed in negative) can be backlit at the telescope. (The book is distributed in the United States by Willmann-Bell, Richmond, Virginia.) ☐

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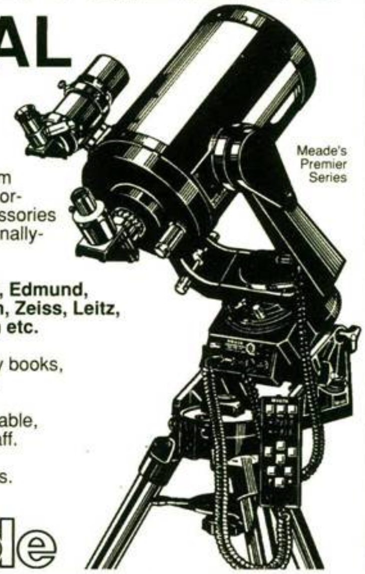

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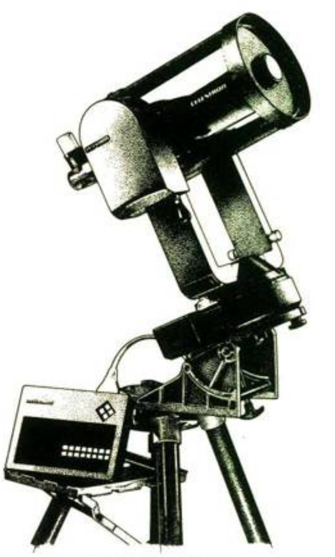

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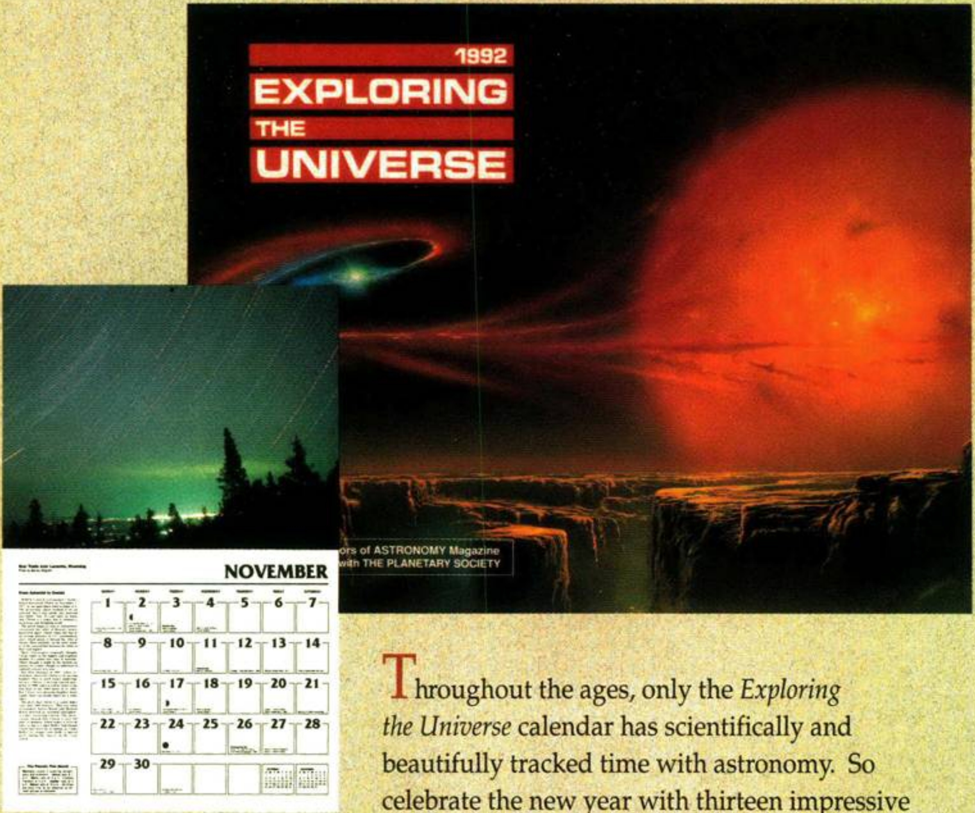

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FOR SALE — The Astrograph, 15 issues, $15 ppd. ZX80, 8k rom, syntax magazine $25 ppd. 1850 Carl Luttigs brass microscope, case, three eyepieces, one objective, original and good condition, $350 ppd. Contact Sweetman, 2961 W. Katapa Trail, Tucson, AZ 85741. Phone, evenings, (602) 297-2781.

ANNOUNCEMENT — The Denver Astronomical Society and the Western Colorado Astronomical Club are co-hosting this year's M.A.R.S. (Mountain Astronomers Rendezvous and Star) Party. Around Deadhorse Point in the Canyonlands of Utah. June 14-16. Everyone invited. Contact Patti Kurtz, The Denver Astronomical Society, P.O. Box 100996, Denver, CO 80210.

FOR SALE — Timex 1000 computer, books and accessories. Space commemorative silver medallion set. Send SASE for list. Contact P. Selhorst, 11478 Road P, Columbus Grove, OH 45830.

WANTED — Correspondence with amateur astronomers of any age. Contact Steve Sutton, P.O. Box 842, Springfield, GA 31329.

WANTED — Out-of-print astronomy books, especially lunar/planetary. Especially seeking Kuiper's Photographic Lunar Atlas (University of Chicago Press); Kopal's Photographic Atlas of the Moon; Lunar Orbiter Photographic Atlas of the Moon (NASA Report SP-206, 1971); The Moon as Viewed by Lunar Orbiter (NASA Report SP-200); First Photographs of the Reverse Side of the Moon (Moscow: Foreign Languages Publishing House, 1960); Firsoff's Moon Atlas; Alter's Lunar Atlas and Pictorial Guide to the Moon. Contact John Borra, 5740 Marvin Lane, No. 178, Boise, ID 83705. Phone (208) 378-8375.

FOR SALE — IDAI reflector, 4.5" f/9 primary; equatorial mount; 0.96" eyepieces: 30, 20, 12.5, 4mm; sun, moon filters; 2x Barlow; 6x15 finder. Great first telescope at $150. Contact Tim DeBenedictis, 229 Commonwealth Ave., Boston, MA 02116. Phone (617) 262-5396.

WANTED — Any and all communication with serious amateur astronomers necessary to begin first-time observation in Costa Rica. I need everything at once, in any kind of condition—preferably used, abused, scratched, disassembled mess of junk to get past customs. Contact Elaine E. Henderson, APDO. 40-5550, Miramar, Costa Rica, Central America.

WANTED — Good condition, non-plastic sextant. Will trade Meade 6" with lenses, stand, motor and camera body. Contact B. A. Blake, 7614 Kilmichael Lane, Dallas, TX 75248. Phone (214) 701-8705.

FOR SALE — ASTRONOMY magazines, March 1974 to Dec. 1990. Missing Sept. through Dec. 1981. All good condition. $275 or best offer, plus shipping. Contact Don McElheny, 5406 Weymouth Dr., Springfield, VA 22151. Phone (703) 978-8257.

WANTED — Argentine student, 18 years old, seeks correspondence with persons worldwide interested in astronomy. Contact Javier Ligocki, 3497 Santa Rosa St. (1602) Florida, Buenos Aires, Argentina, South America.

WANTED — Dynamax 8 parts, especially corrector plate and secondary. Contact H. Vickers, 1528 Kenesaw Ave., Knoxville, TN 37919. Phone, collect, (615) 690-5263.

WANTED — Information about observing with refractors, to be included in book being written for a major publisher. The book will survey the activities of amateur and professional astronomers and groups who use refractors in their observing programs. Also needed are photographs and technical information about large (over 7" aperture) modern refractors (or antique instruments of any size) currently being used in amateur or professional facilities. Descriptions of observatories, mountings, and any accessory equipment used for special purposes is also of interest. All contributions used will be credited. Contact M. Barlow Pepin, 729 N. 4th Ave., Deltona, FL 32725.

Meetings & Events

August 16-18
5th Annual Alberta Star Party, Waterton Homestead Campground, near Waterton Lakes International Peace Park. Contact: Royal Astronomical Society of Canada, Calgary Centre, P. O. Box 2100, Station M, Calgary, Alberta, Canada T2P 2M5. Phone: Rick Ponomar, (403) 381-1332.

August 16-18
Northwoods Starfest, Hobbs Observatory Center, Beaver Creek Reserve, Wisconsin. Sponsored by the Chippewa Falls Astronomical Society. Contact: Bob Elliot, Hobbs Observatory, Route 2, Box 94, Fall Creek, WI 54742. Phone: (715) 877-2787.

August 16-19
2nd Annual Southern Michigan Universal Regional Festival of Stargazers, near Clare, Michigan. Sponsored by the Genesee Astronomical Society. Contact: Richard Walker, 1220 Merkle Street, Ortonville, MI 48462. Phone: (313) 627-9524.

August 23-25
5th Annual Astronomy Rendezvous and Conference, Normal, Illinois. Sponsored by the Twin City Amateur Astronomers. Contact: Sharon MacDonald, P. O. Box 755, Normal, IL 61761. Phone: (309) 827-4885 (evenings).

August 30 - September 1
Nova East '91, Fundy National Park, New Brunswick. Contact: Douglas Pitcairn, 13 Ferguson Road, Dartmouth, Nova Scotia, Canada B3A 4J8.

August 30 - September 2
The Conjunction, Northfield Mountain Environmental Center, Northfield, Massachusetts. Contact: Richard Sanderson, P. O. Box 54, Monson, MA 01057.

September 7
National Astronomy and Spaceflight Show '91, Birmingham, England. Contact: Andrew Lound, Publicity Officer for NASS '91, 110 Sandringham Road, Great Barr, B42 1PQ, England, U. K.

September 6-8
Astrofest '91, Camp Shaw-Waw-Nas-See 4-H Camp, Kankakee, Illinois. Sponsored by the Chicago Astronomical Society. Contact: Astrofest, P. O. Box 596, Tinley Park, IL 60477.

September 6-8
Astronomy Weekend, Blackwater Falls State Park, Davis, West Virginia. Sponsored by the West Virginia Division of Parks and Recreation and the Kanawha Valley Astronomical Society. Contact: Pat Northeimer, Box 490, Davis, WV 26260. Phone: (800) 225-5982.

September 6-8
Oregon Star Party and Campout, Steens Mountain, Oregon. Sponsored by the Rose City Astronomers. Contact: Oregon Star Party, Oregon Museum of Science and Industry, 4015 SW Canyon Road, Portland, OR 97221.

September 7, October 5
7th Annual Blue Ridge Parkway Regional Stargaze, Julian Price Park, near Blowing Rock, North Carolina. Contact: Greg Kirby, Route 3, Box 472, Granite Falls, NC 28630. Phone: (704) 396-7656.

September 8
Blue Mountain Lookout Star Party, near Missoula, Montana. Contact: Glenn Kinsley, Western Montana Astronomical Association, 2836 Caribou Lane, Stevensville, MT 59870. Phone: (406) 777-3209 (after 6 p.m.)

September 12-14
4th Annual Ozarks Star Party, near Joplin, Missouri. Contact: Don Walton, 2626 Illinois, Joplin, MO 64804. Phone: (417) 623-3972.

September 13-14
5th Annual Observing Party, Cathedral Gorge State Park, Panaca, Nevada. Contact: Jim Mellor, Great Western Hotels, 401 South Casino Center Boulevard, Las Vegas, NV 89101. Phone: (800) 634-6635.

September 13-15
Huronia Star Party, near Alliston, Ontario. Sponsored by the South Simcoe Amateur Astronomers. Contact: Henri Van Bemmel, RR #1, Colgan, Ontario, Canada L0G 1G0. Phone: (416) 936-2211

September 13-15
3rd Annual Southern Minnesota Sky Show, near New Ulm, Minnesota. Sponsored by the Minnesota Valley Amateur Astronomers. Contact: Minnesota Valley Amateur Astronomers, Route 4, Box 15A, New Ulm, MN 56073.

September 14
StarConn '91, Wesleyan University, Middletown, Connecticut. Sponsored by the Astronomical Society of Greater Hartford. Contact: Astronomical Society of Greater Hartford, P. O.

Box 2271, Hartford, CT 06145-2271.

October 1-6
8th Annual Okie-Tex Star Party, Lake Murray State Park, near Ardmore, Oklahoma. Sponsored by the Oklahoma City Astronomy Club. Contact: Oklahoma City Astronomy Club, 6616 N.W. 20th, Bethany, OK 73008.

October 3-6
Georgia Star Party, Hard Labor Creek Observatory, Atlanta, Georgia. Sponsored by the Astronomical Society of the Atlantic. Contact: Astronomical Society of the Atlantic, c/o Center for High Angular Resolution Astronomy, Georgia State University, Atlanta, GA 30303. Phone: (404) 651-2932 (days).

October 3-6
Planetarium Association of Canada Biennial Conference, Toronto. Canada. Contact: Ian McGregor, McLaughlin Planetarium, 100 Queen's Park Crescent, Toronto, Ontario, Canada M5S 2C6. Phone: (416) 586-5743.

October 4-5
All Arizona Star Party. Sponsored by the Tucson Amateur Astronomy Association. Contact: Tucson Amateur Astronomy Association, 70 West Forrest Feezor, Tucson, AZ 85747.

October 4-5
AstroAssembly, Seagrave Memorial Observatory, North Scituate, Rhode Island. Sponsored by Skyscrapers, Inc. Contact: Conrad Cardano, 68 Colvintown Road, Coventry, RI 02816. Phone: (401) 828-0702 (evenings).

October 4-5
9th Annual Northern Virginia Telescope Meet, C. M. Crockett Park, Calverton, Virginia. Contact: Al Schumann, 6121 Rivanna Drive, Springfield, VA 22150. Phone: (703) 256-8359.

October 4-6
13th Annual Astronomy Jamboree, Southold, New York. Sponsored by the Custer Institute. Contact: Custer Institute, Main Bayview Road, P. O. Box 1204, Southold, NY 11971. Phone: (516) 765-2626.

October 4-6
Connecticut Star Party, Colebrook, Connecticut. Sponsored by the Astronomical Society of New Haven. Contact: Astronomical Society of New Haven, P. O. Box 3005, New Haven, CT 06515.

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Eastern Iowa Star Party. Contact: Quad Cities Astronomical Society, P. O. Box 3706, Davenport, IA 52806.

October 4-6
3rd Annual Astronomy Workshop, Camp Maskapatoon, Alberta. Sponsored by the Edmonton Centre of the R.A.S.C. Contact: Astronomy Workshop, c/o 8950 Windsor Road, Edmonton, Alberta, Canada T6G 2A2. Phone: Russ Sampson, (403) 439-3474.

October 11-12
Twin Lakes Star Party. Sponsored by the West Kentucky Amateur Astronomers. Contact: Jim Boren, Land between the Lakes, Golden Pond, KY 42211-9001. Phone: (615) 232-7405 (days), (615) 232-6820 (evenings).

October 12
Starfest '91. Contact: Bays Mountain Amateur Astronomers, 853 Bays Mountain Park Road, Kingsport, TN 37663.

October 16-19
27th Annual Conference of the Great Lakes Planetarium Association, Youngstown State University, Youngstown, Ohio. Contact: Warren Young, Ward Beecher Planetarium, Youngstown State University, Youngstown, OH 44555. Phone: (216) 742-3616.

October 18-20
AGAAC Association Congress, Sherbrooke, Québec. Sponsored by the Club des Astronomes de Sherbrooke. Contact: Luc Caya, 1185 Bayeux, Sherbrooke, Québec, Canada. Phone: (819) 562-3992.

October 19
Star Watch '91, Holcomb Observatory, Mooresville, Indiana. Contact: Indiana Astronomical Society, 2 Wilson Drive, Mooresville, IN 46158.

May 9, 1992
Astronomy Day, Contact: Gary Tomlinson, Astronomy Day Coordinator, Public Museum of Grand Rapids, 54 Jefferson SE, Grand Rapids, MI 49503. Phone (616) 456-3987. □

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12.5" to 13.1"	169.00	12.5" to 13.1"	149.00
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Readings and Resources

Venus (page 32)

The issue of *Science* for April 12, 1991, contains the first nine science papers to come from the Magellan mission. Technical and detailed, but well worth looking for; try a large library.

"Update on Magellan" by Robert Burnham, ASTRONOMY, February 1991. New kinds of features are emerging in the radar mapping.

"Magellan Scores at Venus" by David J. Eicher, ASTRONOMY, January 1991. Lots of images.

"The Geology of Venus" by Aleksandr Basilevsky and James W. Head III, in *Annual Reviews of Earth and Planetary Sciences,* 1988. Detailed, up-to-date review of Venus geology written by two leading Venus scientists.

A Quasar Lights Up (page 42)

"Hubble's Brave New Universe" by Jeff Kanipe, ASTRONOMY, September 1991. An overview of what astronomers hope to learn from the Hubble mission.

New Views from Hubble (page 46)

"Hubble Opens New Vistas" by Richard Talcott, ASTRONOMY, February 1991. The first big batch of photo releases from Hubble.

"Hubble Delivers" by Richard Talcott, ASTRONOMY, May 1991. An update on HST's imaging and spectroscopic studies.

The End of Civilization (page 50)

"Demise of the Dinosaurs" by Robert S. Dietz, ASTRONOMY, July 1991. Presents the latest evidence for the impact that may have doomed the dinos 65 million years ago.

"Extinctions — or, Which Way Did They Go?" by Steven M. Stanley, *Earth,* January 1991. A look at the dinosaur extinction controversy from the paleontologist's point of view.

Observing Planetary Nebula (page 76)

Turn Left at Orion by Guy Consolmagno and Dan M. Davis, (Cambridge, 1990). This guide introduces the reader to bright deep-sky objects such as planetary nebulae.

Burnham's Celestial Handbook by Robert Burnham, Jr., (Dover Publications, 1978). A three-volume compendium of data on deep-sky objects.

Atlas of Deep-Sky Splendors by Hans Vehrenberg, (Cambridge University Press, 1983). A beautiful picture book of full-page plates that show hundreds of deep-sky objects to the same scale for easy comparison.

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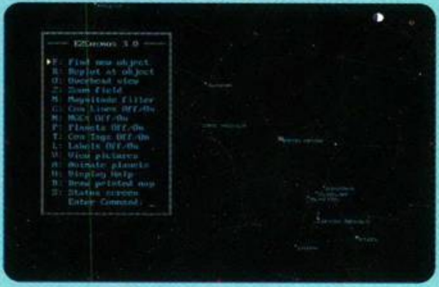
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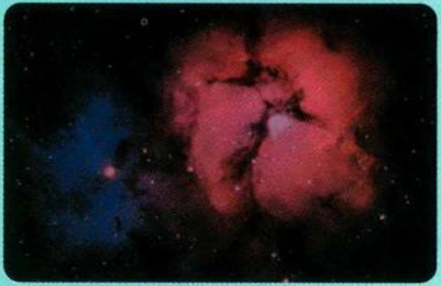

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